Vol. XXVIII, No. 7 *Whole No. 243*

OCTOBER, 1928

SCHOOL SCIENCE AND MATHEMATICS

FOUNDED BY C. E. LINEBARGER

A Journal for all SCIENCE AND MATHEMATICS TEACHERS

CONTENTS:

Published by THE CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS
Publication Office: 404 N. WESLEY AVE., MOUNT MORRIS, ILLINOIS
Business Office: 314 EDGEWOOD AVE., HIGHLAND PARK, ILLINOIS
Editorial Office: 7633 CALUMET AVE., CHICAGO, ILLINOIS

Published monthly, October to June, Inclusive, at Mount Morris, Illinois *Price, $2.50 Per Year: 35 Cents Per Copy*
Entered as second-class matter March 1, 1913, at the Post Office at Mount Morris, Illinois, under the Act of March 3, 1879

Vol. XXVIII, No. 7 *Whole No. 243*

OCTOBER, 1928

SCHOOL SCIENCE AND MATHEMATICS

FOUNDED BY C. E. LINEBARGER

A Journal for all SCIENCE AND MATHEMATICS TEACHERS

CONTENTS:

Published by THE CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS
Publication Office: 404 N. WESLEY AVE., MOUNT MORRIS, ILLINOIS
Business Office: 314 EDGEWOOD AVE., HIGHLAND PARK, ILLINOIS
Editorial Office: 7633 CALUMET AVE., CHICAGO, ILLINOIS

Published monthly, October to June, Inclusive, at Mount Morris, Illinois *Price, $2.50 Per Year; 35 Cents Per Copy*
Entered as second-class matter March 1, 1913, at the Post Office at Mount Morris, Illinois, under the Act of March 3, 1879

"Intelligence is not something possessed once for all. It is in constant process of forming and its retention requires constant alertness in observing consequences, an open-minded will to learn and courage in readjustment."—John Dewey.

CONTENTS *for* OCTOBER, 1928

No Numbers Published for JULY, AUGUST AND SEPTEMBER

Contents of previous issues may be found in the Reader's Guide

School Science and Mathematics

A Journal for All Science and Mathematics Teachers

Published Monthly except July, August and September.

PRICE. The subscription price is Two Dollars and Fifty Cents a year; Canada $2.75; foreign countries $3.00; single copies 35 cents.

ALL REMITTANCES should be made payable to the order of **School Science and Mathematics. Remittances should be made by Post Office Money Order, Express Order, or Bank Draft.** If personal checks are sent, please add five cents for collection. Remit to **School Science and Mathematics, 314 Edgewood Ave., Highland Park, Ill.**

CHANGE OF ADDRESS. Subscribers should send notice of any change of address before the 12th of each month; otherwise they are held responsible for magazine, sent to their former address, and no duplicate copies will be sent except on payment of 35 cents for each copy. Send notices to **School Science and Mathematics, 314 Edgewood Ave., Highland Park, Ill.**

MISSING NUMBERS will be replaced *free* only when claim is made within thirty days after receipt of the number following.

REPRINTS, if desired, must be ordered in advance of publication. Reprints of leading articles will be printed as ordered, the actual cost (with cover, if desired) to be paid for by the author.

MANUSCRIPTS. Contributions on Science and Mathematics Teaching are invited. Articles must be written on one side of the sheet only. All illustrations must be drawn or written in jet black on a separate sheet of manuscript. Contributors are requested to write scientific and proper names with particular care. Manuscripts should be sent to the Editor of **School Science and Mathematics, 7633 Calumet Ave., Chicago,** or to the proper departmental Editor. Books and pamphlets for review should be sent to the Editor.

Entered as Second-Class Matter March 1, 1913, at the Post Office at Mount Morris, Illinois, under the Act of March 3, 1879

SCHOOL SCIENCE AND MATHEMATICS

Vol. XXVIII No. 7 October, 1928 Whole No. 243

CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS.

The Monthly Message.

Our Journal. The members of this Association will be pleased to know that School Science and Mathematics, which has been our official journal for many years, is now owned and published by the Association. After being duly authorized by the Executive Committee the President and the Journal Committee, consisting of T. O. Cantwell, H. R. Smith, and L. E. Hildebrand, incorporated the Association and purchased the Journal from Charles M. Turton and Glen W. Warner, both of whom have been prominent members of our Association for many years. This transaction had the friendly support of many members who furnished the necessary funds by purchasing debentures issued by the Association and secured by the assets of the Journal. Some of our regular advertisers also volunteered support in like manner. Mr. Glen W. Warner has been retained as Editor and Mr. T. O. Cantwell has been appointed as Business Manager.

The Journal Committee. The general policies and management of the Journal will be promoted by a Journal committee. It is hoped that the high educational standard maintained by School Science and Mathematics in the past will be successfully carried forward in the future, and that the committee will be able to recommend added features of merit favored by our members and subscribers. Following is the Journal Committee, three of whom were approved by the debenture holders as provided in the by-laws: Ada L. Weckel, chairman, Oak Park, Ill.; Ira C. Davis, Madison, Wis.; Elliot R. Downing, Chicago; Franklin T. Jones, Cleveland, Ohio; Mabel Sykes, Chicago.

The Annual Meeting. There is every reason to believe that we will have a big meeting at the University of Chicago this year. Some of the speakers who are scheduled on the general program are: John Mills, Bell Telephone Laboratories; Prof. W. T. Bovie, Northwestern University; Prof. Otis W. Caldwell, Columbia University; Prof. Louis C. Karpinski, University of Michigan; Jerome Lederer, Aeronautical Engineer, Aerotech, Inc., Moline, Ill.

The section programs are also very promising and will be published in our next issue.

The Year Book. The Year Book is well under way and will be issued about November first. It will contain a number of new features of special interest, including a brief History of our Association and the new By-Laws. Those who fail to receive a copy should write Miss Ada Weckel, chairman of the Membership Committee

Association Business. The business meeting this year will be of special importance and interest. An attendance much larger than usual is expected. Committees are requested to plan their reports so they may be handled with dispatch. All bills must be presented in writing, with original vouchers attached.

Our Board of Directors. In order to incorporate a Board of Directors of nine members was appointed to hold office until our Annual Meeting. At the Annual Election nine directors will be elected, three directors each for one, two, and three years respectively. Following is our present Board: W. F. Roecker, C. E. Linebarger, T. O. Cantwell, Jos. A. Nyberg, Elliot R. Downing, Herbert R. Smith, L. E. Hildebrand, Mabel Sykes and Ada L. Weckel.

The directors elected the following executive committee for the corporation: W. F. Roecker, C. E. Linebarger, Jos. A. Nyberg.

Journal Debentures. There still remain some unsold debentures which will be sold before the coming Annual Meeting. These debentures expire within ten years, unless called sooner, and bear six percent interest. The list of present holders is gratifying because of its wide distribution and the general participation of all sections.

Debentures may be secured in amounts varying from $10.00 to $500.00. A number of holders subscribed for $50.00 or more; such an amount commends itself because it is similar to a life

membership. Smaller subscriptions are regarded with equal favor by the officers because of the wide interest and the good will they indicate.

By publishing School Science and Mathematics this Association assumes a greater responsibility than it has done heretofore. It is hoped that its educational influence may thereby become more effective and that it may add to the unity and the general co-operation among all teachers of science and mathematics throughout our country. For those who are inclined to promote this outlook a blank is attached below. You are invited to join the original promoters by subscribing for the remaining debentures.

W. F. Roecher, President,
Boys' Technical High School, Milwaukee, Wis.

Date..............................

T. O. Cantwell, Bus. Mgr.,
School Science and Mathematics,
Highland Park, Ill.

Kindly enter my subscription for Central Association Journal

Debentures amounting to.............................. { Enclosed find Check / Will remit Nov. 1, 1928.

Signed..
Address..

CUBA PART OF MAINLAND.

The theories that dry land once united Cuba with the peninsula of Yucatan and that aborigines of Cuba may have been descendants of the famous Maya race of Yucatan are being discussed as a result of discoveries at Lake Mampoton in the province of Pinar del Rio.

A group of American naturalists and archaeologists, cooperating with the Cuban naturalist, Dr. Carlos de la Torre, has just made soundings and excavations at this lake and has unearthed pots and other utensils bearing designs and inscriptions like those of the Maya civilization. In the same Cuban province, Dr. de la Torre has found fossil remains of mammals of a species which still exists in Mexico in the hills of Yucatan and Campeche.

Old Maya legends that tell of the flooding of much land support the theory that long ago these animals wandered afoot across what is now the Straits of Yucatan. Much later, when only the high land of the region remained above the sea to form the island of Cuba, it is suggested that the human migration took place by boat. It is believed that Maya chiefs who had been vanquished by more powerful chieftains fled with their people to the unexplored island to the east and there hid from pursuit.—*Science News-Letter*.

CHAS. M. TURTON, BUSINESS MANAGER EMERITUS.

With the publication of the June number of School Science and Mathematics Charles M. Turton retired from active management of the business and financial affairs of this journal after a period of continuous service of twenty-four years. During this time he has had a large part in transforming a small local journal with about three hundred subscribers to a journal recognized the world over as the most important publication for teachers of science and mathematics. Although reluctant to relinquish this work, it became necessary in order to give him more time to devote to personal affairs and to travel. He will continue as financial advisor until such time as his successor has completely mastered the details of the work.

Mr. Turton was born and reared in the scenic Finger Lake region of New York. He graduated from Syracuse University receiving his A. B. degree in 1883 and his A. M. three years later. He is a member of the honorary fraternity Phi Kappa Phi. In 1893 he accepted a position in the Lake View High

School, Chicago, but the following year transferred to the Bowen, then known as the South Chicago High School, where he taught physics and chemistry for twenty years. Since then he has been head of the science department and teacher of physics. He is joint author of a chemistry manual, two physics manuals and a textbook of physics.

In the fall of 1904, C. E. Lineberger, publisher of the two journals, School Science and School Mathematics, finding the teaching of physics in a large city high school and publishing two educational journals too onerous, sold them to Chas. H. Smith and Chas. M. Turton. They at once combined the two journals into one, SCHOOL SCIENCE AND MATHEMATICS and put out the first issue in January, 1905. Since that time the journal has had a steady growth and is now the recognized clearing house for information and ideas relative to the teaching of mathematics and science.

Mr. Turton will be succeeded by Mr. T. O. Cantwell of Crane College, Chicago. Mr. Cantwell is a young man of fine personality and splendid business ability. With his bountiful supply of energy and the continued advice of Mr. Turton the financial affairs of SCHOOL SCIENCE AND MATHEMATICS will be well administered.

SERUM FOR MEASLES.

The use of convalescent serum from the blood of a person recently recovered from measles is serving to check severe epidemics of measles in cities where it is possible for the health department to obtain this serum. Where the epidemic is predominantly among very young children, however, it becomes difficult to obtain a sufficient supply of the serum, which must be obtained from adults or from older children. In a recent outbreak in Providence it was necessary, according to press reports, to restrict its use to children under four. It will therefore be interesting to follow further reports of the use of measles "anti-diplococcus" goat serum which has already been used with some success in a Chicago epidemic.

This serum was furnished by Dr. Ruth Tunnicliff of the John McCormick Institute for Infectious Diseases. In collaboration with Dr. A. L. Hoyne she succeeded in immunizing goats and in producing a serum which is both antibacterial and antitoxic—which can be counted on, that is, both to destroy the bacteria associated with the disease and to neutralize the poison that they give off. The serum was used for a small group of patients in the Cook County Hospital who had been exposed to measles. Sixty-three per cent were successfully protected. The majority of those who developed the disease experienced it only in a light form. No complication occurred in any of the patients treated in this way, and there was no instance of serum sickness in the entire series. The experimental work seems to point to the possibility of producing a permanent immunity with little risk, by the use of a serum which can be secured in sufficient quantities to meet all the demands.—*Science News-Letter.*

BIOLOGICAL DEFINITIONS IN ELEMENTARY COLLEGE COURSES.

By George E. Nelson,

College of the City of New York.

Biology teachers should give more attention to the educational aspect of their subject. Scarcely any effort has been made to advance the teaching of biology during the last two decades although remarkable strides have been made in the science of biology itself. Undoubtedly, those who have been responsible for this unusual development have been too busily engaged to think of improving the effectiveness of their teaching or of the biology course as an avenue to the acquisition of a liberal education. They have frequently lost sight of the objectives of biological education and attempted to teach much that can hardly be justified in elementary courses. In many institutions these elementary courses have been prescribed for all students. When one considers the fact that less than ten per cent of the students will subsequently enter work requiring a technical knowledge of biology, it is very questionable if such a course can be justified.[1] The mastery of an extensive technical vocabulary or a mass of other details is thus of no particular value to most of the students.

With these facts in mind, it was thought desirable to survey a representative group of American colleges to determine where the stress is being placed in the elementary biology courses, and whether it is in conformity with the objectives of elementary biology teaching. Course content is supposedly selected on the basis of the objectives set for the course. The major objective of elementary biology teaching, as indicated in a large number of college catalogs, committee reports, textbooks, etc., is to provide the students with such materials and intellectual contacts as will best serve the requirements of a liberal education.[2] Final examination question papers include the materials that have been stressed in the course and are better criteria of the importance attached to the various items than a study of the textbooks themselves would be. These questions indicate what has been emphasized and is considered to be vital. They are the nuggets the instructor has sought to plant in the minds of

[1] L. V. Koos, The Junior College. Page 288. "Occupational Destination of College Graduates."

[2] L. V. Koos & C. C. Crawford, "College Aims, Past and Present." School & Society, Vol. XIV. Pages 499-509. Proceedings of Association of American Colleges. 1923.

the students. Materials appearing repeatedly on the examinations of many different instructors are valid items from the teacher's point of view. The frequency of their appearance in the examinations is a measure of this validity and the relative value of the item. In this paper only the definitions that were included on the examinations are rated according to this measure of validity. There probably are a great many more that have high validity by other criteria but never appeared on the examinations. In addition to definitions all the other biological materials on these examinations were similarly arranged and analyzed. These will be summarized at a later date. They include such topics as the general principles of biology, classification of forms, embryology, genetics, economic biology, history of biology, histology, life cycles, adaptations and systematic botany and zoology.

Final examination question files were requested from one hundred representative colleges distributed all over the country. Seventy-one departments of zoology, botany or general biology submitted samples. There were more than three thousand questions, exclusive of those on the objective examination papers. Eight hundred and seventy-seven different definitions appeared on the various question papers. About fifty per cent of these definitions appeared on but one, two or three of the many hundreds of examination papers.

PARTIAL LIST OF DEFINITIONS IN ORDER OF FREQUENCY.

photosynthesis	27	alternation of generations	10	blastula	7
respiration	24	cambium	10	diecious	7
Chromosome	22	ectoderm	10	endosperm	7
Symbiosis	20	geotropism	10	gastrula	7
Enzyme	18	heterospory	10	heterogamy	7
fertilization	18	nitrogencycle	10	hormone	7
osmosis	18	ecology	9	maturation	7
zygote	18	nephridium	9	ovule	7
metamerism	16	tropism	9	parasite	7
metabolism	15	archegonium	8	parasitism	7
metagenesis	15	cell theory	8	physiology	7
coelom	14	chlorophyll	8	plasmolysis	7
mitosis	14	fission	8	regeneration	7
gamete	13	mycelium	8	rhizome	7
saphrophyte	13	nucleus	8	root hair	7
irritability	12	polymorphism	8	secondary sexual character	7
zoospore	12	protein	8	sporophyte	7
cell	11	taxonomy	8	tissue	7
homology	11	transpiration	8	turgor	7
nematocyst	11	analogy	7	Amitosis	6
parthenogenesis	11	archenteron	7	Antheridium	6
protoplasm	11				

biology	6	antimere	4	Collenchyma	3
carpel	6	colony	4	commensalism	3
chromatin	6	conjugation	4	cork	3
contractile vacuole	6	cytoplasm	4	cuticle	3
fermentation	6	endomixis	4	Darwinism	3
gametophyte	6	evolution	4	diffusion	3
gastrulation	6	excretion	4	digestion	3
hermorphrodite	6	fossil	4	dominant character	3
mesogloea	6	histology	4	ecdysis	3
phloem	6	hybridization	4	egg	3
stomata	6	isogamy	4	embryology	3
tracheids	6	meristem tissue	4	epidermis	3
abiogenesis	5	mesoderm	4	epigyny	3
assimilation	5	metazoa	4	eugenics	3
autotomy	5	mutation	4	gonad	3
centrosome	5	neurone	4	haustorium	3
cytology	5	nitrogen fixation	4	hymenium	3
ectoplasm	5	organic evolution	4	hypostome	3
fruit	5	parenchyma	4	lenticel	3
ganglion	5	petiole	4	medusa	3
gene	5	pistil	4	Mendelism	3
germ layer	5	polarity	4	micropyle	3
growth	5	pome	4	monoecious	3
katabolism	5	pseudopodium	4	organ	3
megaspore	5	reflex arc	4	ovary	3
metamorphosis	5	rhizoid	4	paleontology	3
microspore	5	sperm	4	pedicellaria	3
natural selection	5	stigma	4	pileus	3
notochord	5	stimulus	4	pollen grain	3
oospore	5	stipule	4	prostomium	3
paedogenesis	5	strobilus	4	protozoa	3
phototropism	5	trachea	4	raceme	3
protoplast	5	zygospore	4	receptacle	3
reduction division	5	adventitious root	3	reproduction	3
seed	5	aorta	3	sex chromosome	3
stamen	5	ascus	3	sexual reproduction	3
stoma	5	basidium	3	sorus	3
tracheary tissue	5	bast	3	statocyst	3
typhlosole	5	bilateral symmetry	3	synapsis	3
xylem	5	binomial nomenclature	3		
anabolism	4			toxin	3
anther	4	blastopore	3	ureter	3

Some interesting observations were made as to the type of examination questions that are being utilized in elementary courses of botany, zoology and general biology. These relate to the structure of the examination itself. First, is the newer or objective type of examination being extensively employed? Second, what per cent of the questions are of the thought provoking type and how many simply require the use of the memory? Each question was rated independently as either a thought or information question. Questions requiring the application of biological facts, usually the "why" or "how" questions were classed as thought questions. Those requiring simply a statement of fact were classed as information questions.

TYPE OF EXAMINATION EMPLOYED AND NATURE OF QUESTIONS.

Department	Number of Departments	Number using essay type	Number using objective type	Number using both
Botany	26	20	2	4
Zoology	28	21	3	4
General Biology	17	10	2	5
Total	71	51	7	13

	Information Questions	Thought Questions	Per Cent Thought Questions	
Botany	1110	114	10.3	
Zoology	993	112	11.3	
General Biology	581	57	9.8	
Total	2684	283	10.5	

It is apparent that the new type of examination has not been generally accepted by biology teachers, although the objective examination is exceedingly more accurate and efficient as a measure of the student's knowledge of facts. Inasmuch as present examinations are an attempt to measure information (in at least as far as ninety per cent of the materials are concerned), they should be employed more extensively for that purpose. Too many technical definitions are demanded of students who will pursue no advanced work in biology. The final selection of definitions suitable for elementary courses in biology should be determined by the judgments of a number of competent biology teachers and the functional value that the definitions have in actual life.

A CYCLONE MODEL.

BY L. FENNER,
1800 Harrison St., Chicago.

In order to visualize better the shifting of winds as a cyclone passes, have a student procure a piece of glass, one foot square. Have him cut some small arrows from gummed paper. These should be fastened to the glass so as to show the pattern of the whirling winds in a cyclone. A capital L should be affixed in the center. The sharp edges on the glass must be rendered harmless.

When this glass model of the cyclone is moved across the blackboard, or across a wall map of the United States, the student can understand the shifting of the winds for a designated city, and he can attempt the usual predictions.

MAXIMA AND MINIMA AREAS IN GEOMETRY.

By Otto Dunkel,

Washington University, St. Louis, Mo.

Several texts in plane geometry give a treatment of the maximum area of a triangle having a given length of perimeter, and many readers of such texts have the incorrect idea that this treatment constitutes a proof that the equilateral triangle has the greatest area of all triangles with the same length of perimeter. The usual treatment is to prove the following proposition.

Proposition I. *Of all triangles having a given base and a given length of perimeter, the isosceles triangle with the other two sides of equal length has the greatest area.*

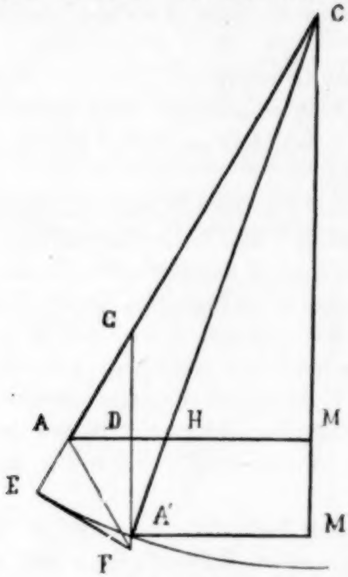
This is then followed by a corollary to the effect that the triangle of maximum area with the given length of perimeter is equilateral. This, however, merely proves that, if there exists a triangle with the given perimeter which has a greater area than any other such triangle, it must be equilateral. But no proof is given that there does exist such a triangle, and without this proof the conclusion cannot be drawn that the equilateral triangle has the greatest area. Stated differently, we may say that the texts prove in the corollary that the necessary condition for a maximum area is that the triangle must be equilateral. But there is no proof given that this condition of equal sides is sufficient to guarantee a maximum area, i. e., that the equilateral triangle has a greater area than any other triangle which satisfies the required condition. Two geometrical proofs of this last fact will be given. The first will be based upon Proposition I in order to complete the treatment of the geometry texts. The second proof is independent of this proposition. It depends upon an intimate relation between the theorem to be proved and the theorem regarding the minimum area of a triangle having an inscribed circle of given radius, such that from either theorem the other may be easily inferred. The third proof will be of a more algebraic character.

We shall now prove the following proposition:

Proposition II. *Of all triangles having a given length of perimeter the equilateral triangle has the greatest area.*

Let S be the area of a triangle with the sides of lengths a, b, c, which are not all equal but such that $a+b+c=3e$, a given length. The equilateral triangle with the same length of perimeter has its sides of length e. Let its area be denoted by E. Let c be the

shortest side of S, then $c<e$. Let S' be the area of the isosceles triangle with the base c and with each of the other two sides equal to $a'=(a+b)/2$. Then by I, $S'>S$ if $a\neq b$, or $S'=S$ if $a=b$. Draw the triangle AMC with a right angle at M and with $AM=e/2$, $AC=e$. Then $\angle MAC=60°$ and AMC is one-half of the



equilateral triangle E. Lay off on MA the length $MD=c/2<e/2$, and produce CA to E so that $AE=AD$. Draw DG the perpendicular to MA at D cutting AC in G. Also draw EF the perpendicular to AE at E cutting GD produced at F, and then draw AF. The triangles ADF and AEF are equal and each has an angle of 60° at A. Thus each of these triangles is equal to ADG, and $GD=DF$. We shall now construct one-half of the isosceles triangle S'. With C as center and radius CE describe an arc of a circle cutting DF in A'. This circle will contain ADG in its interior, while F will lie outside the circle since EF is a tangent at E. Hence $GD=DF>DA'$ or $GA'>2\ DA'$. Draw $A'M'$ perpendicular to CM produced at M', also CA' cutting DM in H. Then $A'M'C$ is one-half of S', for $CA'+A'M'=CA+AE+AM-AD=CA+AM$. Then area $A'GC=A'M'\cdot GA'/2>A'M'\cdot DA'=$ area $A'M'MD$. Now take from each side of the inequality the area of $DA'H$ and their results, area $HDGC>$ area $A'M'MH$. Hence

$$E-S'=2\ [\text{area } ADG+\text{area } HDGC-\text{area } A'M'MH]$$
$$>2 \text{ area } ADG.$$

But $E-S \geqq E-S' > 2$ area ADG, and the proposition is proved. This result may be stated in the following form.

COROLLARY III. *If c is the shortest side of a triangle with sides a, b, c, not all equal, then the area of the equilateral triangle with the side $e=(a+b+c)/3$ exceeds the area of the first triangle by an amount greater than the area of an equilateral triangle with the side of length $e-c$.*

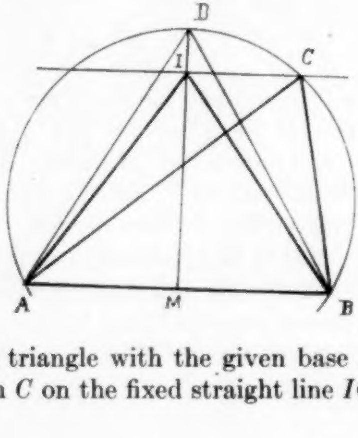
We are now ready to prove

PROPOSITION IV. *Of all triangles circumscribed about a circle of given radius r, the one which is equilateral has the smallest perimeter and the smallest area.*

Let S be the area of a triangle, not equilateral, with the inscribed circle of radius r and with the perimeter $2s$. Let E' be the area of the equilateral triangle with an equal perimeter $2s$; and let r' be the radius of its inscribed circle. Then by II, $E' > S$; but $E' = sr'$ and $S = sr$. Hence $r' > r$. Let E be the area of the equilateral triangle with the inscribed circle of radius r. Then each linear part of E is smaller than the corresponding part of E', since E and E' are similar and $r < r'$. Hence the perimeter $2p$ of E is less than $2s$. Moreover, $E = pr < sr = S$, and this completes the proof.

It is an interesting fact that the proof of II and IV in the reverse order is no more difficult than the above procedure. We shall accordingly give an independent proof of IV by means of a series of propositions and then deduce from it the proposition II.

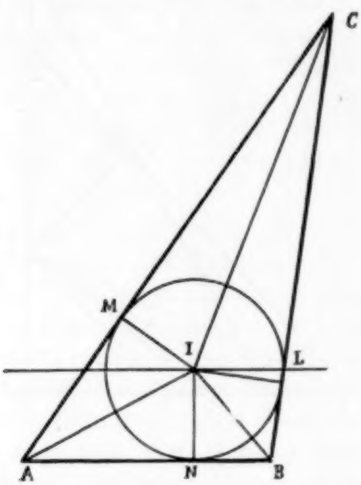
PROPOSITION V. *Of all triangles having the same base with the third vertex on a fixed line parallel to the base, the isosceles triangle with the other two sides equal has the greatest vertical angle.*



Let ABC be a triangle with the given base AB which is not isosceles and with C on the fixed straight line IC parallel to AB.

We may suppose that $AC>BC$. Let MI be the perpendicular to AB at its mid-point M cutting IC in I. Draw the circle through A, B, C; then this circle cuts MI produced in two points. Let D be that point of intersection on the same side of AB as C. Then CI will be one-half of the chord perpendicular to the diameter of which MD is a part. Hence $MD>MI$. The isosceles triangle ADB will contain the vertex I of the isosceles triangle AIB. Hence $\angle AIB > \angle ADB = \angle ACB$. This proof may be easily extended to show that $\angle ACB$ increases as C moves toward I.

PROPOSITION VI. *Of all triangles having the same base and the inscribed circle of a given radius r, the isosceles triangle with the other two sides equal has the minimum perimeter.*



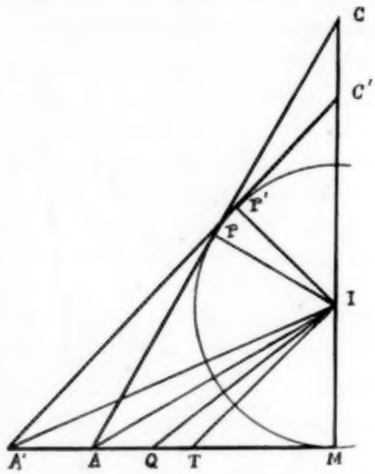
Let ABC be a triangle with the base AB and with the other two sides AC and BC of unequal length. Let I be the center of the inscribed circle and draw the radii IL, IM, IN to the points of contact of the circle with BC, CA, AB, respectively. Draw also AI, BI, CI. From the equality of the three pairs of right triangles having the common vertex I, $AM=AN$, $BN=BL$, $CM=CL$, $\angle MIC = \angle LIC$, $\angle MIA = \angle NIA$, $\angle NIB = \angle LIB$. Hence of the total perimeter the part $MA+AN+NB+BL=2AB$ is constant. Also

$$\angle MIC = 1/2\,[360° - \angle MIA - \angle NIA - \angle NIB - \angle LIB]$$
$$= 1/2\,[360° - 2\angle AIB] = 180° - \angle AIB.$$

The perimeter has a minimum length when MC is a minimum, and this occurs when $\angle MIC$ is a minimum, since MI is of con-

stant length. But $\angle MIC$ is a minimum when $\angle AIB$ is a maximum. By V, this happens when $AI = BI$, i.e., when N bisects AB and then ABC is isosceles.

We shall now prove IV. Let a, b, c be the sides of a triangle, not all equal, with an inscribed circle of radius r. Let us assume that c is the longest side. Then by VI the isosceles triangle with the base c and with the inscribed circle of the same radius r has a smaller perimeter if $a \neq b$. Thus, if a' is the length of the equal sides, $2a' \leqq a+b$. Moreover, $a+b<2c$, and hence $a'<c$. Let $A'B'C'$ be this isosceles triangle, $\angle A' = \angle B'$; then $\angle C' = 180° - 2\angle A'$ and $\angle A' < \angle C'$. Hence $\angle A' < 180° - 2\angle A'$, or $\angle A' < 60°$.



Let M be the middle point of $A'B'$, and draw the right triangle $A'MC'$, one half of the isosceles triangle. Draw $A'I$, the bisector of the angle A', cutting MC' in I; then $MI = r$. Draw IP' perpendicular to AC' at P'; then $\angle MIA' = \angle A'IP'$, $IP' = IM$.

Since $\angle MA'I < 30°$, $\angle MIA' > 60°$. Draw IA cutting MA' in A so that $\angle MIA = 60°$. Reflect the right triangle AMI on AI and let M fall at P. Produce AP until it cuts MC' at C. Then MAC is one half of the equilateral triangle, and M and P are points of contact with the inscribed circle. Also $\angle MIA = \angle AIP = \angle PIC = 60°$. Since $\angle MIA' > 60° = \angle MIA$, $MA' > MA$. Also $\angle PIP' = 2\angle MIA' - 2\angle MIA = 2\angle AIA'$. Lay off on MA' the length $MT = P'C'$ and draw IT. Then $\angle MIT = \angle P'IC'$. Also $\angle TIA = \angle MIA - \angle MIT = \angle PIC' - \angle P'IC' = \angle PIP'$. Hence $\angle TIA = 2\angle AIA'$. Let IQ be the bisector of $\angle TIA$ cutting MA' in Q. Since $IA' > IQ$ and IA bisects the angle between

these two lines, $A'A > AQ$, Similarly, we prove that $AQ > QT$. Hence $A'A > QT$ and $2\,A'A > AQ + QT = AT$. The perimeter of $A'B'C'$ is $2a' + c = 2\,[MA' + A'P' + P'C'] = 2\,[2MA + 2AA' + TM] > 2\,[2MA + AT + TM]$, or $2a' + c > 6MA = 3e$, where $2MA = e$. Hence $2s = a + b + c \geqq 2a' + c > 3e$. Hence the equilateral triangle has a smaller perimeter than ABC.

Let S be the area of ABC, then $S = sr$. Let E be the area of the equilateral triangle with the side e; then $E = 3er/2$. Since $3e < 2s$ $E < S$, and the second part of VI is proved.

We may now prove II as follows: Let S be the area of a triangle, not equilateral, with the given perimeter $2s$. Let r be the radius of the inscribed circle. Let E be the area of the equilateral triangle having the same perimeter $2s$, and let its side be $e = 2s/3$. Let R be the radius of its inscribed circle. Let E' be the area of the equilateral triangle having the inscribed circle of radius r, and let $2s'$ be its perimeter. Then by VI, $2s' < 2s$; and hence E' has each of its linear parts less than the corresponding parts of E. Thus $r < R$ and also $E' < E$. Now $S = sr < sR = E$.

Proposition VII. *Of all rectangles having a given perimeter the square has the greatest area.*

The geometrical proof of this is so obvious that it need not be given. This proposition is inserted here since it is equivalent to the algebraic theorem that the arithmetic mean of two unequal positive quantities is greater than their geometric mean. Most high school algebra texts give a proof of this, but no proof is given for the general case of n positive quantities. This extended theorem gives an easy proof of II, and it is otherwise an important theorem. We shall prove it in

Proposition VIII. *The arithmetic mean of n positive quantities is greater than their geometric mean if the quantities are not all equal. The two means are equal if the n quantities are all equal.*

The second part is obviously true. We shall prove the first part by mathematical induction. Suppose that the proposition is true for the case of any i positive quantities. We shall prove that it must be true also for $(i+1)$ quantities. Let $a_1, a_2, \ldots, a_i, a_{i+1}$ be any $(i+1)$ positive quantities which are not all equal, and let a be their arithmetic mean. Let us assume that a_{i+1} is the smallest so that $a - a_{i+1} > 0$. Then $a_1 + a_2 + \ldots + a_i + a_{i+1} = (i+1)a$. We may write

$$\begin{aligned} a_1 + a_2 + \ldots + a_{i-1} + a_i &= ia + (a - a_{i+1}), \\ a + a + \ldots + a \quad + a_{i+1} &= ia - (a - a_{i+1}), \end{aligned} \qquad (1$$

where in the second equation there are $(i-1)$ of the equal quan-

tities a. By hypothesis

$$\begin{aligned} a_1+a_2+\ldots+a_{i-1} + a_i &\geqq i(a_1a_2\ldots a_i)^{1/i} \\ a+a+\ldots+a + a_{i+1} &\geqq i(a_{i+1}a^{i-1})^{1/i} \end{aligned} \qquad (2$$

From (1) we have

$$(a_1+a_2+\ldots+a_{i-1}+a_i)\ (a+a+\ldots+a+a_{i+1}) = i^2a^2-(a-a_{i+1})^2 < i^2a^2. \qquad (3$$

Then by multiplying the two sides of (2) and using (3) we have in turn

$$\begin{aligned} i^2a^2 &> i^2(a_1a_2\ldots a_ia_{i+1})^{1/i}a^{(i-1)/i}, \\ a^{(i+1)/i} &> (a_1a_2\ldots a_ia_{i+1})^{1/i}, \\ a &> (a_1a_2\ldots a_ia_{i+1})^{1/(i+1)}. \end{aligned}$$

Now for $i=1$ we have from (3) at once $a_1a_2 < a^2$ or $a > (a_1a_2)^{1/2}$. Hence the proposition is true for 2 quantities, and from the above proof it must also be true for 3, then for 4, etc., up to any number n.

We now apply this to prove II. The area S of a triangle is given by the formula

$$S^2 = s(s-a)(s-b)(s-c),$$

where $2s=a+b+c$ is given. Then $s-a$, $s-b$, $s-c$ are positive quantities which are not all equal if we assume that a, b, c are not all equal. The arithmetic mean of the first set of three quantities is $s/3$. Hence $S^2 < s(s/3)^3$. The side of the equilateral triangle with the same perimeter is $2s/3$, and its area by the above formula is $s^2/3\sqrt{3}=E$. Hence $S<E$.

STANFORD TO GIVE THE NEW ED. D. DEGREE.

The Board of Trustees of Stanford University has approved a plan for the establishment of a three-year graduate program of study leading to the professional degree of Doctor of Education (Ed. D.), after much the same plan as that now followed at Harvard. The new degree is to be primarily a professional degree, analogous to traditional degrees in law, medicine and engineering.

The new degree is to be of two types, one to be known as the school administrator type and primarily designed to prepare for school administration and the teaching of education in universities, colleges and normal schools, and the other is to be known as the master-teacher type and primarily designed to prepare a new type of teacher in subject-matter fields for the junior colleges and for small colleges generally.

The creation of a teacher's degree by the leading universities, analogous to the Ph.D. degree in time and scope, was recently recommended by a committee of the American Historical Association.—*Journal of Education*.

Under the single salary schedule recently adopted for schools of Seattle, Wash., the maximum for teachers possessing the bachelor's degree was increased from $2,400 to $2,700. The annual increment was raised from $60 to $100, and the number of increments was reduced from 11 to 8.

MODERN PHYSICS.

By C. F. Hagenow, Ph. D.,
Washington University, St. Louis, Mo.

The following is an attempt to sketch just a few of the more remarkable developments that have taken place in the last thirty years and, more especially, to call the attention of the reader to a few of the outstanding books on these topics; books at once fascinating and authoritative.

One cannot discuss modern physics without realizing that the subject of philosophy has somehow become too deeply entangled in the science to be ignored. This is rather an unfortunate way of putting it, as if philosophy had not always been, in one of its aspects, a sort of clearing house of all the sciences. But what has happened is that the physicist has become acutely aware that his problems were also, at bottom, philosophical ones. One might say he was so busy building on the superstructure that he failed to pay due attention to the foundation; indeed, I feel tempted to say, he often did not realize he needed one. To quote one writer, the new thing is this "disposition to search for and drag to light unconsciously made assumptions."

But a necessarily artificial aloofness from philosophy is only one of many examples of the high degree of specialization of modern sciences. It is legitimate and, in fact, essential to progress along special lines, but one must not forget that it is only a convenient and temporary estrangement. However, whether the physicist was aware of it or not, he could not think about the significance of his experiments without, to that extent, becoming also a philosopher. Perhaps he saw this somewhat more clearly than did a certain character in one of Moliere's plays, who was so surprised to find that he had been talking prose all his life without realizing it.

It was stated that this article on modern physics should deal with a span of thirty years. Now one can be quite precise in this matter and say thirty-three years, because the year 1895 can truly be designated as the beginning of the new era. It is this because this was the year of the discovery of x-rays. To the majority of people, x-rays immediately suggest only shadowgraphs and the various other therapeutical applications. Even the student of physics is at first rather surprised to learn that the early great importance of these rays to science was their ability to ionize gases. By this is meant their property of tearing

off an electron from a gaseous atom, leaving the latter positively charged, i. e. a positive ion.

This was the first intimation that the atom had constituents. For this ionization showed two things. First, that the atom is a complex structure. For, unlike the situation in the case of electrolysis, the resulting parts are not constituents of a neutral molecule, but integral parts of the molecule itself. Thus, even for a monatomic gas like helium, the molecule (atom, in this case) becomes charged. Secondly, the constituents of the atom are electrical in character. This was the simple beginning of one of the most momentous epochs of investigation in the whole history of physics.

Up to this time the atom was held to be just what the word implies, an indivisible thing. That this idea was no mere provisional hypothesis, but what might be called a fundamental philosophical principle, is attested by no less authority than Maxwell, who said in an address before the British association in 1873: "Natural causes, as we know, are at work, which tend to modify, if they do not at length destroy, all the arrangements and dimensions of the earth and the whole solar system. But though in the course of ages catastrophes have occurred and may yet occur in the heavens, though ancient systems may be dissolved and new systems evolved out of their ruins, the molecules (used here in the sense of atoms) out of which these systems are built—the foundation-stones of the material universe—remain unbroken and unworn."

Now Maxwell was a man who had scientific vision, if there ever was one (witness, for example, his electromagnetic theory of light). Dictums of this sort are not so uncommon. There was the assertion, before the days of the spectroscope, that it would be forever impossible to measure the velocity of a star in the line of sight. Among the recent illustrations of this kind one might mention a statement of Poincaré (who has sometimes been likened to Newton on account of the breadth of his knowledge and largeness of vision) to the effect that if through some new experiment a choice were offered between holding to Euclidian geometry and the theory that light traveled in a straight line, the latter would undoubtedly be abandoned. Just the reverse has actually been done in Einstein's relativity theory.

I think one misses the significance of such statements if one regards them as perhaps rather superficial predictions, based on the knowledge of the time and as implying a certain lack of

magination or even fancy. The men who said these things had magination, they had seen certain "impossibilities" come to pass, but their conclusions were based on something broader, namely a certain feeling, or even a craving, for an essential simplicity and finality of the mechanism of the part of the physical world they were studying.

In the introduction to his "Contemporary Physics," Karl Darrow in recounting the qualities of phenomena that attract the investigator, mentions "two qualities of the first importance," one of which is that "some (phenomena) are themselves simple in a way which suggests that theirs is in a sense an ultimate simplicity," and cites as an illustration the motion of the planets and double stars, all calculated on the basis of Newton's law of gravitation and his laws of motion.

The same feeling of completeness and finality in many departments of physics in the early nineties led almost to a feeling of pessimism, as expressed by Paul R. Heyl in his "Fundamental Concepts of Physics in the Light of Modern Discovery." He also quotes a statement, made at this time, which reflects the feeling of many physicists of that period. This sentiment may not have been universal, but it is safe to say that it was, in a large measure, typical. The statement went something like this: "The fundamental discoveries in physics have probably all been made; the work of the twentieth century must be largely in the sixth place of decimals." Then, as someone bluntly put it, the whole bottom dropped out of it, and physics entered on an era that G. N. Lewis very aptly described as the "awkward age of rapid growth." With the splitting up of the atom by x-rays began a new world of discovery, and you see why the year 1895 is such a critical date. In the book of Heyl's just mentioned, the author has very appropriately designated the 18th, 19th and 20th centuries, respectively, as the Century of Materialism, the Century of Correlation and the Century of Hope.

The epoch-making discovery of Röntgen was quickly followed by Becquerel's discovery of radioactivity in 1896, which indeed was a direct result of investigations inspired and suggested by the phenomenon of x-rays. Then came, among others, the new element, radium, a million times as active as uranium. (This activity can be measured by the same property that is associated with x-rays, namely their gas-ionizing property.)

When it was found that 1 gram of radium gave out heat at the rate of 133 calories per hour, an interesting question arose. For

in one year this amounts to over a million calories, while burning the same amount of coal yields only about 8,000 calories. Now the energy of the radium is decreased only .04 per cent in that time, or a practically negligible loss. As a matter of fact it is only about half gone in about 1,700 years. Its total energy is something like a million times as great as can be obtained from a like mass of any other substance by any known chemical transformation. What to do with the principle of conservation of energy? It would seem as if one had a choice of either maintaining this principle and seeking to account for this seemingly exhaustless store of energy by some hitherto unknown transformation, or, in abandoning it, to suppose that in this case energy was really created out of nothing.

The choice that was made is a good illustration of the apparent arbitrariness that the mind seems to possess in formulating the laws of nature. Of course we must not forget that all "science" is man-made. "A purely objective science does not exist." Now all experience and laboratory experiments upheld the principle of conservation of energy (e. g. the impossibility of perpetual motion) and the first alternative was certainly more acceptable both in the light of past experience and regarded as a working principle. Still attempts are sometimes made to abandon it, at least on the molecular scale, and to regard it as a statistical law.

The study of the constitution of the atom, aided principally by x-ray analysis and spectroscopy, soon gave occasion to the building of various atomic models. Here I would like to say something about model building in general. Maxwell likened the situation to the case of a man trying to discover the nature of the mechanism completely hidden from him in a closed box, but through the sides of which a number of strings protruded by means of which he could manipulate the mechanism inside. He pulls a certain string and observes how the others behave in consequence. From such experiments he draws conclusions as to the nature of the mechanism inside. We have this situation when we start to build models of atoms that are to satisfy the various requirements of physical and chemical experiments. Darrow, in the prolegomena of his book mentioned above, discusses some of these models and their respective limitations to the particular requirement for which they were designed. He asks the question: "Granted that several atom-models, each of them designed and adequate for a particular set of facts of its own, are incompatible with one another, what then is to be

done?" He warns the student of physics "to adopt the practice of regarding atom-models as creations of the imagination, as the building stones of mental models designed to copy chosen phenomena of the environing world." He does not minimize the experimental evidence which gives us information about properties of atoms, such as mass, detachable charge, etc., which he calls features of the "experimental atom," but points out that these are adequate each only for the explanation of a certain circumscribed field of experiment. Thus, to quote: "Mass is sufficient to explain the atomic weights of the chemical elements, but additional speculative features must be added to explain valence or chemical affinity," and so on for the other attributes. To him it seems unlikely that these speculative features which are necessary for our atom models will some day be verified by direct experiment and "so enter the category of features of the experimental atom."

The whole question of the "reality" of the atom, the electron or any of the purely inferential entities of physics is a deep one and I, for my part, become lost in a maze of metaphysics in trying to discuss it. It might be worth while, however, to refer to some aspects of it at this stage.

Norman R. Campbell, in his "What is Science?" does not believe in the distinction that is ordinarily made between a law and a theory. To illustrate: We find by experiment that if a given mass of gas has its volume reduced to one-half of its original volume, the pressure is doubled, the temperature being kept constant. This is a "law of nature" (Boyle's law). Now we can "explain" this behavior by assuming that the gas is composed of a great number of perfectly elastic molecules in rapid and random motion, which, by their bombardment of the walls of the containing vessel, produce the pressure observed. It is evident that according to this simple picture, when the volume is diminished as described, the number of blows per second on any given area of the surface of the vessel is doubled, thus agreeing with experiment. This mental picture is part of what is known as the kinetic theory of gases. Thus a law may be said to be discovered and a theory invented. But Campbell holds that laws are no less the product of imaginative thought than theories. He says: "Both laws and theories derive their ultimate value from their concordance with nature and both arise from mental processes of the same kind." One should read the chapter on Conventions and Natural Laws in Russell's "A B C of Relativity" in this

regard. So-called experimental facts are often, in part, the results of the conventions of measurements. Russell gives several instances and says: "This element of convention survives in the laws that you arrive at after you have made your decision as to measures, and often it takes subtle and elusive forms. To eliminate the element of convention is, in fact, extraordinarily difficult; the more the subject is studied, the greater the difficulty is seen to be."

The distinction between what is directly accessible to experiment and what is inferred is not always clear. I remember a statement made in the pre-relativity and pre-quantum times that there was as much reason for existence of the ether as in existence of shoemaker's wax. At that time the wave theory of light was regarded as definitively established. Hence, it seemed an inescapable consequence that there must be a medium to carry these waves. Yet, even then, someone remarked that all we know of the ether is that it is the subject of the verb "to undulate." And Lewis, in his "Anatomy of Science" even refers to this conception of an ether as an "obsession from which we are awakened as from a hideous nightmare."

We come now to the year 1900, which is the birth-year of the quantum theory. You will find a fine chapter on "Waves and Quanta" in the "Contemporary Physics" of Darrow. If the discovery of the compositeness of the atom were a revolutionary physical discovery, the quantum theory might be termed an equally subversive proposal in a field affecting the very basis of physical conceptions. For it denied the continuity of energy. Planck was led to this extremely novel theory by the repeated failures of many theorists to account for the distribution of the intensity of the different wave-lengths in the radiation of a black body.

It was the accepted theory that this radiation was due to the vibrations of the electrons in the atoms of the radiating body, these electrons continuously giving out a long range of frequencies due to the various degrees in which they were held bound in their respective atoms. But Planck showed that it was impossible to account for the observed results except on the supposition that the vibrating electrons did not emit continuously, but only at certain instants when they possessed an amount of energy which occurred in whole number multiples of a quantity of energy hn. Here "h" is the famous Planck's constant and "n" is the frequency of the emitted radiation.

Not much later this quantum was found to appear in and to explain the most varied phenomena, of which I can only mention two. One is the photoelectric effect. As an illustration of this effect, when ordinary light shines on a surface of any of the alkali metals, electrons are given off by that surface. This phenomenon is now widely applied, especially in the transmission of pictures and television. It was found that the velocity of the emitted electron is independent of the intensity of the incident light, but depends on the frequency. In fact, the kinetic energy of the emitted electron is simply equal to the quantity "hn" minus some energy spent in getting out of the metal itself. Note the strangeness of the lack of dependence of the velocity of the electron on the intensity of the light which ejects the electron. Indeed the effect is the same as if the electron had received a bundle of energy hn, undiminished by its journey from the source of light, whereas on the wave theory of light any quantity of energy, starting from the source, would be spread out and attenuated more and more as the distance increased. Also this electron emission occurs at once when the light strikes the metal, whereas a calculation on the wave theory showed that in the case of a light of a candle placed a meter away from the emitting surface, it would require an interval of about 15 minutes before enough energy had been absorbed by an atom to eject a single electron.

Again, when an electron strikes a metal surface, radiation is emitted (x-rays). Now if this radiation falls upon a second surface, electrons will again be emitted, according to the photoelectric effect just described. It was found that the fastest electrons from the second surface have the same velocity as the electrons that strike the first one. (The energy lost in getting out of the surface is negligible in this case.) That is, the energy of the "secondary electrons" depends only on the energy of the primary electrons, not on the nature of the material of either primary or secondary surfaces nor on the distance through which the radiation travels. This remarkable fact was illustrated by Sir William Bragg as follows. "It is as if one dropped a plank into the sea from a height of 100 feet and found that the spreading ripple was able, after traveling 1,000 miles and becoming infinitesimal in comparison with its original amount, to act upon a wooden ship in such a way that a plank of that ship flew out of its place to a height of 100 feet."

Another great success of the quantum theory is in its applica-

tion to what is called the "Bohr atom." On the older theory the vibrating electron gave rise to light waves and many were the vain attempts to devise an electrical or mechanical system which would emit the frequencies that were actually found in the simplest of atoms, the hydrogen atom. The formula that had to be derived from theoretical considerations, and which was first found empirically by Balmer, is so simple that I shall present it here. For one of the series of lines in the hydrogen spectrum the frequencies are given very accurately by

$$n = N\left(\frac{1}{a^2} - \frac{1}{b^2}\right),$$

where $a = 2$ and b takes the values 3, 4, 5, and so on for the different lines. N is a constant. Multiplying by "h,"

$$hn = Nh/a^2 - Nh/b^2.$$

Now you have a certain amount of energy associated with the frequency n, and you will remember that hn was found also in the photoelectric effect as an energy which the electron received from the incident light. Thus this energy is seen to be the difference between two energies and Bohr interpreted these as the energies the electron possessed, respectively, in each of two orbits, the energy of radiation represented by the difference being emitted when the electron jumped from one orbit to the other. At each jump a sort of "package" of energy equal to hn is emitted, in light of the frequency n. There is here a clear contradiction to the classical theory of electrodynamics which requires that radiation be emitted by the electron as it moves in its orbit. Since the energy of this radiation would have to be provided by the moving electron, the result would be the final collapse of the latter into the nucleus. Moreover, in so doing the frequency would change and sharp line spectrum would be impossible. The Bohr theory has been enormously fruitful, though the difficulties when atoms of more than one electron are considered are truly formidable.

It is one of the most significant signs of the times and of the extraordinary vigor of present-day physics that the Bohr theory, young as it is, is already being crowded by a number of remarkable and ingenious rival theories to account for the spectral behavior of the atom. Of these the most promising "competitor" is probably the Schrödinger wave theory of the electron. Unfortunately, however, the comparatively simple "mechanical pictures," so dear to the older physicists, are receding more and more into the background and are being replaced by more purely mathematical structures.

The greatest difficulty of all is the present irreconcilability of the quantum theory with the wave theory of light. As you have just seen, the former implies that light is emitted in packages equal to hn; in the photoelectric effect an electron cannot be ejected unless it receives at least an amount equal to hn. All these phenomena seem to demand some kind of a corpuscular nature of light, while such phenomena as interference and diffraction are impossible of explanation except on some sort of wave theory. Diffraction phenomena may be seen everywhere. Look at a distant light through a handkerchief, a raised umbrella or Pullman window-screen. Thus, we have the situation of two perfectly good theories, each satisfactory in its own domain but as yet no bridge across the gap; a condition of affairs which caused Bragg to remark that we would adopt the wave theory on Mondays, Wednesdays and Fridays and the quantum theory on Tuesdays, Thursdays and Saturdays.

As in the case of the quantum theory, the theory of relativity, also, touches the foundations on which physical science is based. Perhaps one might say even more so. The atomicity of energy might be regarded as at least having a predecessor in the theory of the atomicity of matter and, in fact, Einstein himself showed that even on the classical theory radiant energy would have inertia. But the relativity of time, e. g., was distinctly a departure. According to Newton: "Absolute, true and mathematical time flows in virtue of its own nature uniformly and without reference to any external object." It is now definitely related to space.

Just what is it that the relativity theory concerns itself with? You will find one of the best discussions of this matter in Chapter II of Bertrand Russell's "A B C of Relativity." In any experiment the actual data obtained by the observer depend on a number of factors peculiar to the conditions under which the investigator is working and not an essential feature of the phenomenon studied. As a crude illustration, suppose two observers are measuring the speed of a passenger train, one making his measurements from the station, the other from a slow freight train. They will, of course, obtain different figures but, allowing for the velocity of the freight train, the moving observer will arrive at the same result as the stationary observer. Now relativity has to do with the principle of taking into account the accidental and unessential conditions that environ a given ob-

server. Let me quote Russell: "Physics is intended to give information about what really occurs in the physical world, and not only about the private perceptions of separate observers. Physics must, therefore, be concerned with those features which a physical process has in common for all observers, since such features alone can be regarded as belonging to the physical occurrence itself. This requires that the laws of phenomena should be the same whether the phenomena are described as they appear to one observer or as they appear to another. This single principle is the generating motive of the whole theory of relativity."

Einstein, confining himself to the case of observers moving uniformly with respect to each other, announced his theory of "restricted relativity" in 1905. The restricted theory grew out of experiments such as the famous Michelson-Morley experiment, which showed that the velocity of light was a constant quantity, regardless of the motion of the observer. Paradoxically as it may seem, this means that, in the illustration used just above, the observer at the station and the observer on the slow freight would each obtain the same number representing the velocity of the passenger train relatively to him. With this as a postulate, the logical consequences were that time and space could no longer be regarded as distinct factors of a given phenomenon, which could be separately arrived at as a residue, after due allowance has been made for the accidental conditions under which the observations were taken; space and time were merely partial aspects of an event occurring in "space-time." As a matter of fact, all our observations are conditioned upon both space and time. You might say that you are observing certain geometrical or physical relations at the same instant and so time is automatically cancelled out, but the question has arisen, what is the same instant at different places?

Now after all allowances have been made for the particular conditions under which different observers have obtained their data concerning a given phenomenon the residue, the something which remains constant for all observers, is the *interval* between two events. However different the quota in distance and time by which this interval is measured by a number of observers, this interval seems to be the intrinsic attribute of the phenomenon in question. It is expressed by

$$c^2t^2-(x^2+y^2+z^2)=\text{a constant},$$

where c is the velocity of light. Note the analogy to the purely spacial invariant

$$r^2 = x^2 + y^2 + z^2,$$

which occurs in the rotation of a set of rectangular axes, keeping the origin of coordinates fixed. In the latter case, though each observer, using his own set of axes, obtains values of x, y and z differing from those of the other observers for the same point in space, yet they will all obtain the same value of r.

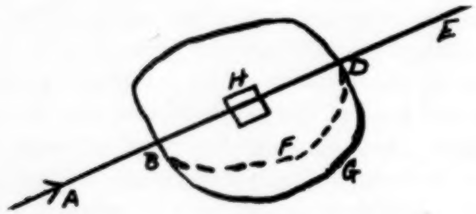
All of the above has to do only with the effects of uniform relative motion. Now what is to be done about pruning away all the accidental and local conditions for two observers, one of whom is accelerating with respect to the other, taking data on the same phenomena? Einstein's solution of this formidable problem appeared in 1915. This theory involved two new concepts, one as to the geometry of space and the other the inclusion of gravitation into a new geometry. Where Newton postulated a "force" to account for departure of the motion of the planets from a straight line, Einstein has no need of a force, but ascribes their motion to the nature of space itself. Now let me remind you that this is a physical theory and not a mere matter of speculation; that is, it is a theory that can be put in a form susceptible to verification by experiment or observation. Two of three remarkable verifications have already appeared as "news of the day." I refer to the bending of the light rays passing near the sun and the advance of the perihelion of the planet Mercury. However, to do this, Einstein had need of a geometry quite different from the one we have always been accustomed to, viz., the Euclidian. At this point it is best to proceed with analogies. Let us confine ourselves to two dimensions.

If you lay off a right triangle on the ground you can verify, by actual measurement, the Pythagorean theorem, $c^2 = a^2 + b^2$. Now, laying off a very large figure of this sort, say several miles on a side, a believer in a flat earth would be puzzled to find this famous theorem to fail, for now c^2 is less than $a^2 + b^2$. If he had no idea of a third dimension and you explained to him that his triangle was curved, he would not understand you. In the same way it might puzzle the normal individual if, in regarding a Mercator's map of the Atlantic ocean, he became aware that the ship, in sailing by the shortest route to a point directly east, actually left the parallel of latitude it was on and traveled north for a while. (Arc of a great circle being the shortest distance between two points on the surface of a sphere.) Considered as

a surface only, a spherical surface is not Euclidian. There is a delightful story illustrating this point in the "Anatomy of Science," by G. N. Lewis. The book as a whole is charmingly written and by a scientist of the first rank.

Now, according to Einstein, we have to consider a space-time world of three space and one time dimension, and this is not Euclidian, near a large mass, in this general theory. To connect up with the analogy above, we can imagine this four dimensional space-time curved into a fifth dimension. Now notice carefully that this is itself only a sort of analogy, for this fifth dimension is neither space nor time. As a matter of fact, there is no one geometry, but different geometries depending on the distribution of matter. Far from any matter, the space-time is Euclidian. (It might be added that, to describe all the properties of space, it would require ten dimensions in space if it were Euclidian.)

As another illustration, and remember it is again only a picture in space alone, while in the theory it would apply (in an unimaginable way) to the space-time continuum, as it is called, I should like to give one which is also contained in the book of Lewis mentioned above.



The figure represents a crater with a house in the middle at H. A traveler wishes to go from A to E by the shortest path. He will not proceed along the path ABHDE, i. e., through the house at the bottom of the crater, as this may be too long. Likewise the path ABGDE may be too long. But he may find that some such path as ABFDE, part of the way down the crater, is shorter than any other. An observer from an airplane, not being aware of the crater, thinks the surface flat and concludes that the traveler makes a detour because someone in the house is directing a hose at the intruder. On closer examination he finds this hypothesis untenable, perhaps tries other assumptions; finally the mystery is cleared up by the discovery that the house is in a crater.

Russell says: "Just as geometry has become physics, so, in a sense, physics has become geometry. The law of gravitation has become the geometrical law that everybody pursues the easiest course from place to place, but this course is affected by the hills and valleys that are encountered on the road." Thus, again, we seem to have a certain freedom of choice. We can keep ordinary geometry plus force (which, however, becomes more and more difficult to handle) or use the new geometry, with no force; but this new geometry promises to be of a most intricate and abstruse kind.

I shall conclude with a very significant paragraph from Russell: "What we know about the physical world, I repeat, is much more abstract than was formerly supposed. Between bodies there are occurrences, such as light-waves: of the laws of these occurrences we know something—just so much as can be expressed in mathematical formulae—but of their nature we know nothing. Of the bodies themselves, as we saw in the preceding chapter, we know so little that we cannot even be sure that they are anything: they may be merely groups of events in other places, those events which we should naturally regard as their effects. We naturally interpret the world pictorially: that is to say, we imagine that what goes on is more or less like what we see. But in fact this likeness can only extend to certain formal logical properties expressing structure, so that all we can know is certain general characteristics of its changes. Perhaps an illustration may make the matter clear. Between a piece of orchestral music as played, and the same piece of music as printed in the score, there is a certain resemblance, which may be described as a resemblance of structure. The resemblance is of such a sort that, when you know the rules, you can infer the music from the score or score from the music. But suppose you had been stone-deaf from birth, but had lived among musical people. You could understand, if you had learned to speak and to do lip-reading, that the musical scores represented something quite different from themselves in intrinsic quality, though similar in structure. The value of music would be completely unimaginable to you, but you could infer all its mathematical characteristics, since they are the same as those of the score. Now our knowledge of nature is something like this. We can read the scores, and infer just so much as our stone-deaf person could have inferred about music. But we have not the advantages which he derived from association with musical people. We cannot know whether the

music represented by the scores is beautiful or hideous; perhaps, in the last analysis, we cannot be quite sure that the scores represent anything but themselves. But this is a doubt which the physicist, in his professional capacity, cannot permit himself to entertain."

BIBLIOGRAPHY.

General

"The Anatomy of Science," by G. N. Lewis, Yale University Press.

"The Fundamental Concepts of Physics in the Light of Modern Discovery," by Paul R. Heyl, The Williams and Walker Company, 1926.

"Introduction to Contemporary Physics," by Karl K. Darrow, Van Nostrand Co., 1926.

"Science and the Modern World," by A. N. Whitehead, Macmillan Co., 1925.

"What is Science?" by N. R. Campbell, Methuen and Co., London.

Atoms.

"The A B C of Atoms," by Bertrand Russell, E. P. Dutton and Company, 1923.

"Atomic Theory," by Arthur Haas, Constable, London, 1927.

"Stars and Atoms," by A. S. Eddington, Yale University Press, 1927.

Relativity.

"The A B C of Relativity," by Bertrand Russell, Harper and Brothers, 1926.

THE PHYSICS CLASS MEASURES BLOOD PRESSURE.

BY D. C. BARRUS,

Head of Science, Mount Hermon School, Mount Hermon, Mass.

An interesting diversion for a physics class studying liquid pressure may be had by assembling a simple apparatus for measuring the blood pressure. The apparatus can be easily put together by two or three students and the experiment is simple enough for them to perform. It will probably appeal to students who have a leaning toward medicine.

Clamp a U glass tube with one arm at least 40 cm. long to a meter stick in such a way that the tube will be in a vertical position and the meter stick may be used to record levels in mercury. The U-tube should have a small bore, both ends open and a sufficient supply of mercury in it so that a pressure of at least 120 millimeters may be measured. To the shorter arm of the U-tube connect by means of three or four feet of rubber tubing a rubber sack like a toy balloon. Inserted between the rubber sack and the manometer (U-tube) there should be a T-tube for the purpose of attaching an atomizer bulb. All connections should be air-tight.

In order to make the measurement of the blood pressure bind the rubber sack to the inner side of the upper arm of some member of the class. Use a wide bandage and make it rather firm but not tight enough to stop the flow of blood. Find the pulse in the wrist of the bandaged arm. With the atomizer bulb slowly inflate the rubber sack until the pulse just disappears. The difference in the mercury levels in the manometer indicates the blood pressure. The writer has found it more satisfactory to have a slow leak in the apparatus and take the readings at the instant that the pulse can first be detected after the flow of blood had been completely stopped by the inflation of the sack.

THE STUDY OF FORESTRY.

By M. Barbara Dee,
Jamaica Plain High School, Boston, Mass.

Introduction.

The importance of the study of forestry at the present time is to me self-evident. The difficulty is to find room for it in an already overcrowded curriculum. It is usually given consideration in a course in biology, the amount varying in modern text-books from two pages to an entire chapter. The writer suggests the following outline as a not too extensive amplification of the usual treatment. It aims to be suggestive merely. Neither is the list of references exhaustive. Those given have proved useful in actual classroom practice. Those marked with a star are of a more elementary or popular nature; the others may need simplification and condensation with the aid of the teacher or should be assigned only to the more mature pupils. A large amount of new pamphlet material is being published all the time. The most valuable sources for this are the National Forestry Service, The American Tree Association and The American Forestry Association, all of Washington, D. C.

Books Used.

Bruncken, E.—North American Forests and Forestry.
Hawley and Hawes—Manual of Forestry.
*Moon—The Book of Forestry.
Noyes—Wood and Forest.
*Pack—Our Vanishing Forests.
*Pinchot—The Training of a Forester.
*Price—The Land We Live In.
*Roth—First Book of Forestry.
U. S. Department of Forestry Bulletins 173 and 358.
New Hampshire State College Bulletins.
*Pamphlets from Munson-Whitaker Company, Boston.
Hawley—Practice of Silviculture.
Pinchot—Primer of Forestry, 1 and 2.
*Pack, C. L.—A School Book of Forestry.
Hales, B. J.—Forests and Trees.
Crumley, J. J.—Constructive Forestry.
*Pack—Trees as Good Citizens.
Fernow, B. E.—A Brief History of Forestry.
R. Zon & Sparhawk—Forest Resources of the World.
Care of New Tree Plantings (University of Iowa).
*Floods, Forests and the Future (American Tree Association).
*The Forest Products Laboratory—Madison, Wis.
*Forest Service U. S. Department of Agriculture—Pamphlets.
The Forest As An Investment on Non-Agricultural Land in Iowa. (McDonald, University of Iowa).
*Forestry As A Career—National Research Council.
*The Junior Forester in the U. S.—(United States Forest Service).
*Pamphlets of American Tree Association.
*Forest Conservation—American Forestry Association.
*Chemical Treasures of the Forest—American Forestry Association.

General Organization of the Study of Forestry.

I—What Wood Does for Us.

1. Our Homes.
2. The Railroads.
3. The Telegraph and Telephone.
4. Coal.
5. Chemical Uses of Wood.
6. The Turpentine Industry.
7. Maple Sugar.
8. Paper.
9. General Uses of Wood.
10. The Forest and Floods.
11. The Forest and Wild Life.
12. The Forest and Climate.

II—The History of the Forest.

1. In the Old World.
2. In the New World.

III—Our Forests of Today.

1. The Three American Forests.
2. The Present Extent and Value of Our Timber Lands.
3. National, State and Town Forests.

IV—The Forest Organism.

1. Soil.
2. Moisture.
3. Temperature.
4. Light.

V—How the Tree Grows.

VI—Wood.

1. Its Structure.
2. Its Properties.
3. A Comparison with Iron—The Possibility of Substitutes.

VII—Enemies of the Forest.

1. Weather.
2. Plants.
3. Animals.
4. Insects.
5. Fire.
6. Man's Activities.

VIII—What We Can Do to Help Our Forests.

1. The Protection of the Forest.
2. Starting the New Forest.
3. Modern Forestry.

IX—Some Other Ways in Which We Can Use Trees.

1. Park and Shade Trees.
2. Landscape Forestry.

Additional Topics.

1. Silvicultural Forests.

GENERAL ORGANIZATION OF THE STUDY OF FORESTRY.

I—What Wood Does for Us.

1. Our Homes—Ref., Pack, Chap. 1.

2. The Railroads—Ref., Pack, Chap. 2.

3. The Telegraph and Telephone—Ref., Pack, Chap. 3.

4. Coal—Ref., Pack, Chap. 5.

5. Chemical Uses of Wood—Ref., Pack, Chap. 8; Chemical Treasurers of the Forest 3, 4, 5, 6.

6. The Turpentine Industry—Ref., Pack, Chap. 7; Roth, pp. 174-177; Moon, pp. 141-144; Chemical Treasurers of the Forest, 7.

7. Maple Sugar—Ref., Pack, Chap. 7; Moon, pp. 136-138.

8. Paper—Ref., Pack, Chaps. 6, 7; Moon, pp. 138-140; Chemical Treasurers of the Forest, 2.

9. General Uses of Wood—Ref., Pack, Chap. 4; Forest Conservation, 1; Bruncken, pp. 60-65; Chemical Treasures of the Forest, 1.

10. The Forest and Floods—Ref., Pack, Chap. 10; Do Forests Prevent Floods? Moon, pp. 11-16; Bull. 358, pp. 36-40; Moore, pp. 14-37; Hales, pp. 15-18.

11. The Forest and Wild Life—Ref., Pack, pp. 88-89; Roth, pp. 180-182; Moon, pp. 16-18; Pack (School Bk.), Chap. 4; Forest Conservation, 3, 4, 5.

12. The Forest and Climate—Ref., Bulletin 350, pp. 24-26; Moon, pp. 1-14; Pinchot (Primer 2), pp. 56-63; Crumley, pp. 224-226.

II—The History of the Forest.

1. In the Old World—Ref., Roth, pp. 214-216; Bull. 358, pp. 40-44; Fernow (selections); Pinchot (Primer 2), pp. 74-80; Zon & Sparhawk 1, Chap. 2 (selections).

2. In the New World—Ref., Bruncken, Chap. 3; Moon, pp.

4-8; Bull. 358, pp. 44-48; Fernow, pp. 461-504; Forest Products Laboratory, Chap. 2.

III—Our Forests of Today.

1. The Three American Forests—Ref., Roth, pp. 209-213; Noyes, Chap. 4; Bruncken, pp. 5-16.

2. The Present Extent and Value of Our Timber Lands—Ref., Roth, pp. 213-214; Pack, pp. 90-94; Bruncken, pp. 89-96; 264-269; Price, pp. 228-232; Zon & Sparhawk 2, Chap. 4; Hales, pp. 8-14; Pack (School Bk.), Chap. 14, 18; Forest Conservation, 7; Primer 1, 2, 3, 4, 12, 14.

3. National State and Town Forests—Ref., Bulletins—National Forester; Town Forestry; Pamphlets of American Tree Association.

IV—The Forest Organism.

1. Soil—Ref., Roth, pp. 18-24; Noyes, pp. 211-213.

2. Moisture—Ref., Roth, pp. 24-32; Noyes, p. 213; Bulletin 172, pp. 16-17; Pinchot (Primer) 1, pp. 26-30.

3. Temperatures—Ref., Roth, pp. 32-37; Noyes, pp. 214-216.

4. Light—Ref., Roth, pp. 14-18; Noyes, pp. 216-218; Bulletin 173, pp. 17-18; Pinchot (Primer) 1, pp. 30-36; Crumley, pp. 55-57; Bruncken, pp. 17-24.

V—How the Tree Grows.

Ref., Moon, Chap. 4; Bulletin 173, pp. 9-11; Pinchot (Primer) 1, pp. 18, 36-37, 44-67; Pack (School Book), Chap. I, Care of New Tree Plantings.

VI—Wood.

1. Its Structure—Ref., Roth, pp. 217-227; Moon, pp. 51-57; Noyes, Chap. 1; Bulletin 173, pp. 11-15; Pinchot (Primer 1), pp. 19-24.

2. Its Properties—Ref., Moon, pp. 57-60; Roth, pp. 227-232; Noyes, Chap. 2.

3. A Comparison With Iron—The Possibility of Substitutes—Ref., Roth, pp. 232-238; Moon, pp. 60-62.

4. Important Forest Trees and Their Uses—Ref., Pack (School Book), Chap. 5.

VII—Enemies of the Forest.

1. The Weather—Ref., Moon, pp. 105-106; Noyes, pp. 229-233; Bulletin 173, pp. 38-41; Pinchot (Primer), pp. 75-77; Crumley, pp. 123-127.

2. Plants—Ref., Noyes, pp. 233-237; Moon, pp. 103-105;

Hawley & Hawes, pp. 124-136; Bulletin 173, p. 38; Pinchot (Primer I), pp. 74-75; Pack (Trees), Chap. 18; Hales, pp. 51-53; Crumley, pp. 120-123; Pack (Second Book), pp. 67-70.

3. Animals—Ref., Moon, pp. 102-103; Noyes, pp. 237-248; Hawley & Hawes, pp. 104-124; Bulletin 173, p. 35; Hawley, Chap. 16, p. 219, pp. 284-288; Pinchot (Primer I), pp. 69-74.

4. Insects—Ref., Moon, pp. 102-103; Noyes, pp. 239-248; Hawley & Hawes, pp. 104-124; Bulletin 173, p. 38; Hawley, Chap. 16; Pack (School Book), pp. 64-66; Primer, Chap. 6; Bruncken, pp. 119-120.

5. Fire—Ref., Noyes, pp. 251-257; Moon, pp. 92-100; Bruncken, pp. 98-111; Hales, pp. 24-38; Hawley & Hawes, pp. 136-143; 157-161; Primer, 5; Pinchot (Primer I), pp. 77-83; Pack (Second book), pp. 53-60; Hawley, pp. 215, 217-218, Ch. 19; Crumley, pp. 129-134; Forest Conservation, II; Forest Fires and (Repr.)

6. Man's Activities—Ref., Bruncken, pp. 96-97; Noyes, pp. 258-263; Hawley & Hawes, pp. 100-104; Bulletin 173, pp. 35-38; Pinchot (Primer I), pp. 67-69; Hales, pp. 21-24; Crumley, pp. 110-111; Primer 7.

VIII—What We Can Do to Help Our Forests.

1. The Protection of the Forest: a. Against Injury from the Elements—Ref., Roth, pp. 131-133; Massachusetts Agricultural College Pamphlets; Pack (Trees), Chap. 16. b. Against Injurious Plants—Ref., Noyes, p. 234; Roth, pp. 131-133; Pack (Trees), Chap. 18; Hales, pp. 71-72. c. Against Animals—Ref., Roth, pp. 115-131; Hawley, pp. 288-290; Pack (Trees), Chap. 19; Hales, pp. 68-71. d. Against Fire—Ref., Roth, pp. 104-112; Noyes, pp. 257-258; Moon, pp. 95-101; Hawley & Hawes, pp. 143-147; Bulletin 173, pp. 41-47; Pack, Chap. 13; Pinchot (Primer I), pp. 83-88; Bruncken, Chap. 9; Pack (School Book), pp. 60-63.

2. Starting the New Forest: a. The Art of Utilizing the Forest—Ref., Bruncken, pp. 121-139; Roth, pp. 182-184; Noyes, pp. 284-286; Pack (School Book), Chap. 13; Pack, pp. 94-98. b. The Protective Forest—Ref., Bruncken, pp. 166-173; Roth, pp. 203-209; Price, Chap. 2; Bulletin 258, pp. 3-5, 7-8; Hales, pp. 55-56. c. The Financially Productive Forest—Ref., Bruncken, pp. 140-144; Moon, Chap. 6; Pack (School Book), Chap. 17; Pack, Chaps. 15, 17, 8; MacDonald, Forestry as a Career; Forest Products Laboratory, Part I.

3. Modern Forestry: a. What Forestry Is—Ref., Moon,

Chap. 1; Pinchot, pp. 18-19, 23-30; Bruncken, pp. 121-124.
b. Our Present Forestry Service—National, State, Town and Private—Ref., Moon, pp. 170-177; Pinchot, pp. 30-46, 84-114; Pack (Trees), Chap. 20; Pack (Our Vanishing Forests), Ch. 14, 16; Primer, Chap. 8, 9, 13; Bruncken, pp. 232-244; Pack (School Book), Chaps. 8, 9, 11, 12; Graves, Public Regulation of Private Forests (Society for Preservation of New Hampshire Forests); Federal to State Responsibilities in Forestry (Reprint from American Forestry); Our Most Urgent Public Park (Reprint); Forest Conservation, Chaps. 6, 7; Bulletin of National Forestry Service.

IX—Some Other Ways in Which We Can Use Trees.

1. Park and Shade Trees—Ref., Moon, Chap. 13; New Hampshire College Bulletins, Bulletin 358, pp. 14-15; Pack (Trees), Chap. 1, 13, 22; Crumley pp. 239-250.
2. Landscape Forestry—Ref., Munson-Whitaker Pamphlets.

Additional Topics.

1. Silvicultural Forests—Ref., Bulletin 358, pp. 7-29; Pinchot (Primer II), pp. 7-56; Crumley, Chapter 7.

OUTLINE AND SUMMARY FOR REVIEW OF FORESTRY (BASED ON THE PAMPHLET—"THE A-B-C OF FORESTRY," ISSUED BY THE N. Y. STATE COLLEGE OF FORESTRY, SYRACUSE, NEW YORK.)

I. What Is Forestry?

A. Its primary object is the reproduction and increase of our wood crop. For this it must:—1. Make forests grow as rapidly as possible, aiding this by protecting the trees from their natural enemies; 2. Produce woods of valuable kinds and sizes, by proper harvesting of trees at the right age, and utilization of all parts; 3. See that young trees take the places of old ones as they are removed.

B. Its secondary objects are: 1. The maintenance of a forest cover on steep slopes; a. To reduce the danger of floods in spring; b. To prevent the drying-up of streams and rivers in summer; c. To eliminate washing away of soil. 2. To provide forests for hunting, camping, and other recreational purposes.

II. The Tree Itself.

A. The Parts of the Tree. 1. The roots: a. Anchor or hold the tree in place; b. Take up from the soil water and soluble salts which the tree needs in its growth. 2. The trunk: a. Heart-wood —dry, hard, and usually darker colored; b. Sapwood—the last

several years of growth; c. The cambium or growing layer; d. The bark—a protective covering—new layers formed each year on the inner side. 3. The crown: a. The network of branches, twigs, and leaves.

B. How Trees Grow: 1. The formation of the annual rings of growth in the stem: a. In the spring, when growth is rapid, the wood cells are large and thin-walled, their primary function being the conduction of water; b. Later in the summer, they are smaller and thicker walled, being chiefly for support. 2. Growth in height and spread of branches: a. The formation of new twigs developing and stretching out from buds; b. These twigs lengthen only during the first year, after which their length remains fixed, and they increase in thickness by annual growth rings; c. Further growth in height or width by the formation of new twigs each year. 3. Rate of growth: a. Giant Sequoia of California—3,000 years old, height 350 feet, diameter 35 feet; b. Eastern White Pine—age 300 years, diameter 3 feet; c. Aspen—age 70 years, height 80 feet. 4. Reproduction: a. By seeds; b. By sprouts. 5. Vital processes: a. Assimilation—water and mineral salts from the roots, combined with carbon dioxide and water from the air, and transformed into plant food by the action of chlorophyll and sunlight. b. Transpiration—surplus water from roots disposed of by evaporation from all parts of tree above ground, but especially from leaves. c. Respiration—the taking in of oxygen and giving off of carbon dioxide.

III. Requirements of Trees.

A. Temperatures.

B. Moisture.

C. Light: 1. Tolerant trees thrive in shade; 2. Intolerant trees require light.

IV. The Life of the Forest.

A. Mutual Helpfulness: 1. Protection of each other from wind, snow and hot sun; 2. The deposit of humus on the soil; 3. More rapid growth in height, giving better form; 4. Natural pruning and the elimination of knots.

B. The Struggle for Existence: 1. Competition for water, space, and light; 2. More seedlings die in the struggle than live to become large trees.

V. Divisions of Trees.

A. Conifers—those which bear cones and generally retain their leaves throughout the winter.

B. Deciduous—having broad leaves which they generally shed in the winter.

VI. Principles of Forestry.

A. Study of each area to determine its particular needs and treatment.

B. Maintenance of good conditions, or improvement of poor ones: 1. Protection from: a. Fire; b. Destructive insects; c. Fungus diseases. 2. Removal of dead or badly damaged trees, or those of poor form, or of inferior kinds. 3. Thinning out of poorer trees in crowded areas. 4. Cutting and utilizing of mature trees in such a way as not to injure the young trees. 5. Making provision to insure new growth.

VII. Why We Need Forests.

A. To furnish innumerable wood products.

B. For stream flow regulation and the prevention of erosion.

C. Recreational uses.

VIII. Why We Need Forestry.

A. Exhaustion of our timber supply demands: 1. The growth of more timber; 2. The more effective use of what we have.

B. Our essential needs for wood cannot be reduced.

IX. Progress of Forestry in the United States.

A. Practiced in Europe for hundreds of years, but only thought of in this country for the last 50 years, and real work done only for 20 years.

B. The awakening: 1. Most of nation originally covered with finest timber, which was supposed to be inexhaustible; 2. Recent awakening to prevalence of barren and desolate wastes in place of original forests.

C. Government Forestry: 1. 1881—Division of Forestry in Department of Agriculture, only for gathering and distribution of information; 2. 1891—Reservation of public timber lands—at present 148 National Forests, comprising 156,000 acres; 3. 1897—Laws for protection of National Forests; 4. 1905—Management transferred to new National Forest Service.

D. State Forestry—at present in 33 out of 49 states.

E. Town and City Forestry: 1. Old idea in Europe: a. Zurich has owned a forest for 1,000 years; b. No taxes in some of German Black Forest towns, because revenue is derived from town forests; 2. Consists in proper planting with trees and maintenance of waste land on outskirts of cities.

F. Forestry by Private Owners: 1. Hitherto not much incentive for commercial companies, as forest land was so cheap; 2. At present there is an increasing interest in it; a. To prevent constant transfers of industry to new lands; b. Somewhat dis-

couraged by unjust taxation and inadequate fire protection.

X. What Is Needed.

A. Increase in Public Forests.

B. Practice of forestry in privately owned forests.

XI. Important Phases of Forestry.

A. Protection from fire, fungus diseases, and insect pests.

B. Proper cutting of our remaining forests.

C. Putting to work of idle, forestable lands.

A SIMPLIFIED TABLE FOR OTIS I. Q.

By H. V. Main,

Harrison Technical High School, Chicago.

To make the finding of the I. Q. from the results derived when using the Otis Self Administering Tests easier and safer, I have devised the following table based upon the table of norms given in the manual.

Years	12	13	14	15	16	17	18
Birth Month							
Aug	77	72	68	64	61	59	58
July	76	72	68	64	61	59	
June	76	71	67	63	61	59	
May	75	71	67	63	60	59	
Apr	75	71	67	63	60	59	
Mar	75	70	66	63	60	59	
Feb	74	70	66	62	60	58	
Jan	74	70	66	62	60	58	
Dec	73	69	65	62	60	58	
Nov	73	69	65	62	59	58	
Oct	73	69	65	61	59	58	
Sept	72	68	64	61	59	58	

To find the I. Q. by this table find the number under the age in years at the last birthday and opposite the birth month. Add the number to the score, or number of right answers, the total is the I. Q. For example the pupil is 15 in May, for the score use 45, the number questions he answered correctly. Under 15 and opposite May is the number 63 which added to 45 gives 108 the I. Q.

This particular table is arranged for use early in September, hence birthdays in August are considered as in even years, no months. Birthdays in July make the pupil one month older so the second line for two months in the table in the manual, is marked July and so on down the other months. If the test is used in some other month than September the names of the months will have to be arranged accordingly. If form B is used four points are to be added to the numbers given here.

The derivation of this table is as follows. The age norm is subtracted from 100 to obtain the numbers for the corresponding ages. The month of the test is used for the last line if the test is given early in the month. Each later month is written in turn on the preceding line so that the past month is on the first line as indicated in the table.

The use of this table eliminates the calculation of the age in months from the information given by the pupil. It eliminates a subtraction, and gives at one reading the desired number to add to the score, for any age. It is much easier to read than the chart given in with the tests.

THE RELATIVE VALUES OF UNIFIED AND CORRELATED MATHEMATICS IN PRESENTING THE FUNDAMENTAL OPERATIONS.

By Raymond R. Wallace,

West Division High School, Milwaukee, Wis.

The literature of the reorganization or fusion of secondary mathematics presents different terms which are descriptive of a new type of mathematics. The terms "correlated," "unified," "general," and "composite" have been used to describe the new forms of organization, in which the obvious and important interrelations between arithmetic, algebra, geometry and trigonometry are recognized and used in presenting the various mathematical courses.

The above mentioned terms mean more or less the same thing or various degrees of the same thing. Correlation means that an attempt is made to profit freely from the existing relation between the various subjects. Unification attempts to do this much more systematically. The term correlated was at one time used to describe a combination of mathematics and science. The idea was that the courses in mathematics should be enriched by science, and, secondly, that in each course in mathematics there should be an interweaving of previous courses in mathematics. Unified implies a grouping together of related ideas which are to be taught together in some natural manner. In unified mathematics, elementary algebra, for example, would still be largely elementary algebra, but it would be enriched by the abundant use of arithmetic where arithmetic would serve as a means of teaching the algebra. Geometrical illustrations which were not forced should also be used for enrichment. General when applied to mathematics means much the same as when applied to science. The various subjects are to be taught in close relation. The material may be arranged according to the parallel plan, or it may be mixed. Composite has not been used much and has no very definite meaning when applied to mathematics.

If we are somewhat baffled at the number of terms describing the reorganized secondary mathematical materials, we certainly are nonplussed when we examine the wide variety of textbooks on reorganized mathematics. There seems to be little agreement among these new textbooks in regard to the space allotted to the various topics, their order of presentation, or method of introduction. Some topics which are given considerable attention by

some authors are omitted altogether by others. Mathematicians agree in general that algebra should be enriched by the use of geometrical materials but there is a difference of opinion as to where, how, and with what the enriching should be done. A beginning in the fusing of the various subjects has been made but much experimental evidence needs to be presented in order to determine just what mixture will produce the best results.

The experiment described below was undertaken to obtain a partial solution of the above problem. It was an attempt to find an answer to the following question: Will the achievements of the pupils of two ninth-grade classes of equal mental ability be the same in certain topics of ninth-grade mathematics if the methods and materials used in presenting these topics to one class are unlike those used in the other class? The topics selected for study were addition, subtraction, multiplication, and division of signed numbers. The removal of parentheses was included in the above topics. This experiment was carried out in the schools of Green Bay, Wisconsin.

A measure of the mental ability of the two classes taking part in the experiment was obtained by giving Terman's Group Test of Mental Ability (for Grades VII to XII). From the scores made on this test the intelligence quotient of each pupil was determined. The reading quotient of each pupil was obtained from the scores made by the classes on the Thorndike-McCall Reading Scale (F2). A measure of each pupil's ability to solve reasoning problems in arithmetic was obtained by giving Buckingham's Scale for Problems in Arithmetic (Form 1, 3rd Division). The results obtained on these preliminary tests were used in arranging the pupils of the two classes so that the mental ability of one class would be equal to that of the other. The results obtained on these tests are given in Table I.

TABLE I. SHOWING MEAN INTELLIGENCE QUOTIENTS, MEAN READING QUOTIENTS, MEAN SCORES MADE ON BUCKINGHAM'S SCALE FOR PROBLEMS IN ARITHMETIC.

	Mean Intelligence Quotients	Mean Reading Quotients	Mean Scores Buckingham Test
Class A	96.52 ± 1.44	94.09 ± 1.97	74.43 ± 0.88
Class B	97.00 ± 1.69	94.10 ± 1.90	76.10 ± 1.13
Difference	.48	.01	1.67
P. E. (Dif.)	2.22	2.74	1.43

Since the actual difference must be at least three times the probable error of difference in order to be significant, it follows that there is no significant difference between the classes shown by any of the above tests. Therefore, for purposes of the experiment, the following conclusions may be drawn:

1. The two classes are equal in general intelligence.
2. They are equal in reading ability.
3. They are equal in ability to solve reasoning problems in arithmetic.

It was decided to present the fundamental operations to Class A using only the methods and materials of a unified mathematics and to present the same topics to Class B using only the methods and materials of a correlated mathematics. These methods and materials are sufficiently different from each other to show any difference in achievement, which might be produced. The former methods and materials used were of the more conservative type. The latter contained much more material of a geometrical nature.

The following brief outline of addition will serve to show the difference between the materials and procedure used in presenting the fundamental operations to the two classes.

ADDITION (CLASS A).

1. Development of the concept of negative numbers by questions and exercises about temperature, directions, latitude, profit and loss, etc.
2. Presentation of the number scale. The pupils were allowed to use this if they so desired but were not required to use it in the solution of any exercises.
3. Exercises and problems in adding signed numbers.
4. Exercises and problems in adding monomials.
5. Exercises and problems in adding polynomials.
6. Review. The amount depended upon the time and progress of the other class.

ADDITION (CLASS B).

1. Graphical addition. The concept of negative numbers was not necessary for the solution of any of the exercises. Example. Let m and n denote two numbers. Representing m and n by line segments, find the sum of $m+3n$.
   a. Exercises illustrating some of the simpler axioms such as, The whole equals the sum of its parts, etc.
   b. Commutative and associative laws of addition. Parentheses.
2. Development of the concept of negative numbers by questions and exercises about temperature, direction, latitude, profit and loss, etc.
3. Presentation and use of the number scale.
4. Graphical addition of signed numbers.
5. Exercises and problems in adding signed numbers.
6. Exercises and problems in adding monòmials.
7. Exercises and problems in adding polynomials.
8. Review. The amount depended upon the time and progress of the other class.

The achievements of each pupil in the topics under consideration were measured by their reactions to four different tests, which were given upon the completion of each topic and the completion of all four topics. These tests consisted of a flash card test, true-false test, completion test, and problem test. These tests except the flash card test were given in mimeographed form.

The flash card test in each topic consisted of fifty exercises in monomials. Each exercise was exposed to the view of the classes on a card four by six inches for a period of seven seconds. The pupils recorded only the answers after the numbers of the exercises. The number of correct answers found on each paper constituted the score. The flash card test given at the end of the experiment consisted of sixty exercises in monomials—fifteen from each topic under consideration and was scored as the other flash card tests were scored.

The true-false test in each topic consisted of twenty statements, approximately half of which were true and half false. The pupils were directed to indicate the true statements by means of a plus sign and the false statements by means of a minus sign. The scores on the true-false tests were obtained by subtracting the number of statements marked incorrectly from the number marked correctly. The true-false test given at the end of the experiment consisted of fifty statements. This test covered all four of the topics under consideration and was scored as the other true-false tests were scored.

The completion test in each topic consisted of twenty incomplete statements; the missing words being indicated by blanks. The pupils were directed to put a word in each blank so that the statements would make complete mathematical sense. The scores on the completion tests consisted of the number of statements successfully completed. Partly completed statements received no credit. The completion test given at the end of the experiment consisted of fifty incomplete statements covering the four topics under consideration. It was scored as the other completion tests were scored.

The problem test in each topic consisted of five questions which were divided into two or more parts. These tests were made up entirely of problems and were marked in percent with one hundred as a basis. The problem test given at the end of the experiment consisted of ten questions, which covered the four topics under consideration.

The experiment was begun in September and continued throughout the first semester of the school year. It was completed about the first of February. The first three weeks were spent in reviewing the work of arithmetic and in introducing the subject of algebra. As soon as the pupils had become somewhat settled and accustomed to their new surroundings, the preliminary tests were begun. These were followed by a rearrangement of the classes in order that two classes of equal mental ability might be had for purposes of the experiment. The pupils involved in the experiment had previously had no instruction in algebra. As soon as all necessary rearrangements were completed, the work in addition of directed numbers was begun. The same instructor was in charge of both classes. As soon as both classes had finished the work in addition, the four tests previously described were given. The same plan was followed in presenting subtraction, multiplication, and division. In case one class was able to complete the materials of the topic which it was studying before the other class completed that topic, the first class spent the time reviewing the topic until the other class had completed it. Thus the time element was kept constant for each topic and for the entire experiment. Every precaution was made to prevent the pupils of one class from having access to the materials used in the other. All tests were marked by the instructor in charge of the classes in order that the personal element in marking would be as nearly constant in both classes as possible. An earnest attempt was made to favor neither type of materials in the selection of test questions.

It was thought advisable to supplement the data obtained during and at the close of the experiment with a measure of each pupil's efficiency in the fundamental operations two months after the close of the experiment. Accordingly a problem test of a somewhat different nature from those used during the experiment was devised and given to both classes about eight weeks after the close of the experiment. The scores on this test consisted of the number of problems correctly done. The mean scores for both classes on this test are given in Table VII.

It may be seen by reference to these tables that on none of the tests was the difference as much as three times the probable error of difference. Therefore there is no significant difference between these classes in their achievements on these tests.

The mean achievements of the classes on the various tests previously described are given in Tables II to VII.

TABLE II. MEAN ACHIEVEMENTS IN ADDITION.

	Flash Card	True False	Completion	Problem
Class A	38.57±0.85	15.17±0.71	16.13±0.57	77.09±1.41
Class B	36.62±1.03	15.67±0.72	17.95±0.61	76.52±1.89
Difference	1.95	.50	1.82	.57
P. E. (Dif.)	1.34	1.01	.83	2.36

TABLE III. MEAN ACHIEVEMENTS IN SUBSTRACTION.

	Flash Crad	True False	Completion	Problem
Class A	40.17±1.07	12.30±0.69	14.48±0.49	72.48±2.64
Class B	41.05±0.77	12.95±0.49	13.95±0.41	66.05±2.49
Difference	.88	.65	.53	6.43
P. E. (Dif.)	1.32	.85	.64	3.63

TABLE IV. MEAN ACHIEVEMENTS IN MULTIPLICATION.

	Flash Card	True False	Completion	Problem
Class A	36.17±0.67	10.22±0.69	14.26±0.52	82.52±1.83
Class B	34.62±1.34	10.29±0.41	13.71±0.48	72.90±3.14
Difference	1.55	.07	.55	9.62
P. E. (Dif.)	1.50	.80	.71	3.63

TABLE V. MEAN ACHIEVEMENTS IN DIVISION.

	Flash Card	True False	Completion	Problem
Class A	37.00±0.70	11.91±0.63	13.96±0.49	71.65±2.58
Class B	35.29±0.80	10.24±0.56	13.38±0.38	64.38±2.86
Difference	1.71	1.67	.58	7.27
P. E. (Dif.)	1.06	.84	.62	3.85

TABLE VI. MEAN ACHIEVEMENTS IN ALL THE FUNDAMENTAL OPERATIONS.

	Flash Card	True False	Completion	Problem
Class A	46.35±1.35	34.13±1.16	32.57±1.06	82.52±1.53
Class B	45.05±1.14	32.05±1.13	30.62±1.04	74.05±2.88
Difference	1.30	2.08	1.95	8.47
P. E. (Dif.)	1.77	1.62	1.48	3.26

TABLE VII. MEAN ACHIEVEMENTS IN THE FUNDAMENTAL OPERATIONS. TWO MONTHS AFTER THE CLOSE OF THE EXPERIMENT.

	Class A	Class B
Mean Score	10.96 ± 0.44	9.19 ± 0.45
Difference	1.77	
P. E. Difference	.63	

SUMMARY AND CONCLUSIONS.

The results obtained in this experiment lead to the following conclusions:

(1) On the basis of a statistical treatment of the data obtained in this experimental study, it appears that there is no significant difference between the achievements of these classes on the work of the experiment.

(2) Even though the differences between the results of the two classes are not significant, the cumulative findings seem to favor the methods and materials used in Class A. The mean scores of this class are higher than those of Class B on 16 of the 21 tests given. The greatest difference was found in their ability to solve algebraic problems.

(3) To what extent the different methods and materials used in presenting the fundamental operations would be carried over into the solution of geometrical problems and reasoning problems in algebra was not determined. It might be that the methods and materials used in presenting the fundamental operations to Class B would be transferred to the solution of geometrical problems to a greater degree and in a greater number of cases than those used in Class A.

(4) It was not the purpose of this experiment to study any transfer of training which might result. The purpose was to determine the relative efficiency of certain methods and materials in developing the ability on the part of the pupils to add, subtract, multiply, and divide directed numbers.

SAMPLES OF THE TEST QUESTIONS GIVEN AT THE END OF THE EXPERIMENT.

1. Flash Card.

	-17	$-1/3$	5.3	$-5x^3$
Addition.	24	$3/6$	-6.6	$-2x^3$
	$3/4rs$	3^2	$-2/3a^2$	
Multiplication.	$2/3rs^2$	3^3	$3a$	$(-2)^5$

2. True-False.
   1. A polynomial is a figure of four sides.

16. In subtraction the sum of the remainder and subtrahend equals the minuend.
32. In the expression $2x-y-3x-1$, the terms are similar with respect to x.
44. n^0 equals 0.

3. Completion.
11. To multiply a polynomial by a monomial, ... each term of the .... by the .... and combine the ....
22. If the dividend be .... and the .... any number not 0, the quotient is 0.
36. The area of a rectangle equals the product of the .... by the ....
46. The distance around a figure is called the ....

4. Problem.
3. Substract:

$$\begin{array}{r} 6x-9y+15z \\ -6x+3y-\ 2z \\ \hline \end{array} \quad (6\%)$$

Check your solution with $x=3$, $y=2$, and $z=1$. (4%)

5. Multiply: $y^2-10y+3$ by $y-6$. (6%)
Check your solution with $y=3$. (4%)
7. Divide: $8x^4+6x^3+9x^2+3x+2$ by $4x^2+x+2$. (6%)
Check your solution by multiplication. (4%)
9. Find the area of a triangle having an altitude of $2x+3$ft. and a base of $x+6$ ft. (10%)

FRESH PRODUCE IN THE CLEVELAND MARKETS.

By Villa B. Smith,

Department of Geography, School of Education, Western Reserve University, Cleveland, Ohio.

Fresh fruits and vegetables are today an essential part of our diet. In our large cities they are always available in all seasons. The sources of the fresh produce sold in any city in a week, month or year reveal interesting and important geography.

To demonstrate the practical importance of this phase of geography work, a study of the sources of fresh fruits and vegetables for sale in Cleveland, Ohio, is here presented. In 1927, 16,825 carlots of such foods were received, the only states not contributing being Vermont, Rhode Island and Connecticut. California contributed the greatest number of carlots, followed by Florida, New York and Georgia in the order named.

The following Table shows the number of carlots received from these states, the leading shipments and the vegetable shipments which rank first and second in importance.

Table 1.

Carlots received in Cleveland from four leading states during 1927.

State	Total Carlots	Greatest Shipments	Vegetables 1st Rank	Vegetables 2nd Rank
California	4,631	Grapes, 1,522	Lettuce, 631	Celery, 52
Florida	1,885	Citrus, 989	Celery, 277	Potatoes, 203
New York	1,191	Apples, 384	Cabbage, 264	Potatoes, 242
Georgia	939	Watermelons, 537	Potatoes, 15	Sweet Potatoes, 3

The total vegetable shipments for the year and their points of origin are indicated in the following Table.

TABLE 2.

Total vegetable shipments received in Cleveland during 1927.

Vegetables	Carlots	States Contributing	Importations
Potatoes	3,703	33	7 carlots
Lettuce	1,033	11	
Onions	748	19	127 carlots
Cabbage	728	16	
Sweet Potatoes	655	14	
Tomatoes	465	12	74 carlots
Celery	423	5	

The states contributing the largest shipments of each vegetable are indicated in Table 3.

TABLE 3.

States sending Cleveland largest vegetable shipments during 1927.

State	Vegetable	Carlots
Maine	Potatoes	726
California	Lettuce	631
Ohio	Onions	163
New York	Cabbage	264
Tennessee	Sweet Potatoes	230
Florida	Tomatoes	152
Florida	Celery	277

The foregoing data indicate the magnitude of the business in fresh fruits and vegetables, and show that Cleveland is dependent upon many distant areas for its most common food products.

It is worthwhile to investigate such food stuffs, to find the regions from which they come, the conditions under which they are produced and the reasons why areas specialize in some crops and not in others. Such an investigation would lead to an understanding of geographic factors governing production and to an appreciation of the interdependence of regions. It would call for a study and interpretation of maps and for the application of geographic principles.

Since the above data are for a year they cannot indicate the daily contributions of each region or the seasonal changes within the regions. Such information is available in market reports published in the Cleveland Plain Dealer. From this material, maps might be made for any time desired.

Such a map is here presented for Oct. 1, 1927. (Map 1) The areas contributing fresh vegetables to Cleveland at that time are indicated and their crops named. The market report furnished the names of the vegetables and the states of their origin. The

Map 1 Sources of fresh vegetables received in Cleveland, October 1, 1927.
From Market Report. Cleveland Plain Dealer.

production maps of the 1925 Year Book of the United States Department of Agriculture and the shipping lists of the Bureau of Agricultural Economics furnished information as to places of origin within the states.

The map shows that potatoes were supplied by Maine, New York, Michigan, Wisconsin, Idaho and Colorado. Cabbage, cauliflower and cucumbers came from New York; rutabagas from Ontario; onions from Ohio, Indiana, Michigan and Iowa; green beans from Tennessee and sweet potatoes from the middle Atlantic states. California supplied lettuce, green peas, onions and garlic; Colorado, cauliflower, green peas and lettuce. The greatest number of fresh vegetables came from the home district, beets, cabbage, carrots, cauliflower, celery, egg plant, green beans, green peppers, sweet corn and tomatoes all being home grown.

To show a midwinter situation a map was made for Feb. 23, 1928. (See Map 2) At this time the state of Sinaloa in western Mexico, furnished green peas, tomatoes and peppers. The lower Rio Grande and Gulf Coast of Texas supplied carrots, spinach, radishes, new potatoes, beets, broccoli and cabbage. Louisiana contributed sweet potatoes, parsley, chicory, romaine, escarole and shallots. Florida was the source of new potatoes, celery, peppers, beans, tomatoes, egg plant and cabbage. California

contributed artichokes, cauliflower, brussels sprouts and lettuce, the latter crop coming from an area further south than the one contributing in October. Arizona supplied cauliflower; Missouri, horseradish; Virginia, kale; Tennessee and Delaware, sweet potatoes. Illinois and Indiana greenhouses contributed cucumbers; Ohio greenhouses, lettuce and mushrooms. Northern and western states furnished potatoes as in October, but the crop was harvested the previous fall and held for later distribution.

This map records a decided shift in vegetable areas from those of October. In February the Cleveland district was supplying only hot-house and storage crops and the areas contributing the bulk of the fresh vegetables were far to the south. The heavy production in the Gulf region is one of the outstanding features of the map. Another is the southern shift in the California producing area.

The source of foods is interesting and the geographical reasons accounting for their production in these localities gives basal ideas of the different occupations.

To account for crop production one must consider the underlying geographic factors—the physical features of the region, the rainfall, temperature, length of growing season, soil, railroad facilities and market. Such information is supplied by maps, especially those found in Goode's School Atlas. Skill in the interpretation of such maps is acquired only through use. Since the many problems presented by daily market reports require the constant and intelligent use of maps, the pupil acquires skill by solving practical and current problems.

To show how such maps may account for the areas supplying Cleveland with vegetables, let us consider the vegetables used in greatest quantities. Table 2 shows that potatoes outrank all other vegetables, and that in the course of a year this commodity moves into Cleveland from thirty-three different states On Feb. 23 (see Map 2) both old and new potatoes were in the market, the former coming from Maine, New York, Michigan, Wisconsin, Minnesota, Idaho and Colorado, and the latter from Florida and Texas. The old crop had been in storage, the new was moving to market immediately after its harvest.

Consulting the physical map of the United States, it is seen that most of the potato areas in the northeast and central states are from 500 to 1,000 feet in elevation. The areas in Idaho and Colorado are chiefly in intermontane valleys. The soil map shows brown gravelly and stony loams, silt loams and sands to

Map 2 Sources of fresh vegetables received in Cleveland, February 23, 1928.
From Market Report. Cleveland Plain Dealer

be the characteristic soils of the potato areas. Most of these are of glacial origin. The rainfall map indicates that part of the district is supplied with 30 to 40 inches of rain, but that other sections have a range from 20 to 30 inches, and some others, the western districts, have less than 20 inches. The higher altitude of the western lands probably accounts for the adequacy of the light rainfall. The light soils in the regions of heavy rainfall account for the crop's tolerance ot abundant water.

The maps showing length of growing season indicate that much of the district has an early frost Oct. 1 and a late spring frost May 1, thus having only four months free from frost. Most of the eastern district has sunshine fifty percent of the time, but as we go west the percentage of sunshine increases. The temperature map indicates that most of the district lies close to the July isotherm of 68 degrees Fahrenheit.

The population map shows that for the most part the areas of potato production are not regions of dense urban population, but that they are situated close to such areas. The railroad map shows that the areas east of the 100th meridian are well supplied with transportation lines and that the western areas have adequate transportation facilities.

From the foregoing it is clear that the northern areas find potatoes a crop adapted to their short, cool summers and glacial soils. Since the crop can be stored, the surplus of the season is marketed throughout the winter and early spring. Cleveland with a dense population requires large potato shipments throughout the year. The nearby producing states are logical sources for such a commodity.

On Feb. 23, the southern areas in Florida and Texas are sending new potatoes north. This is a season when northern areas are unable to furnish a new crop, so the southern product is in demand. Florida and Texas are able to meet the demand by planting potatoes in the late fall and winter, a time when their areas are close to the isotherm of 68 degrees Fahrenheit. Their cool season is brief but since potatoes are a short season crop there is adequate time for them to mature. The soil of the early southern potato areas is chiefly sand, which would be warmer for winter crops than clay or heavy soils.

If market reports are consulted it is found that as the season progresses the areas supplying Cleveland new potatoes move northward. This is easily accounted for, since the warmer days, unfavorable for potato culture, reach the southern areas first. The crop simply progresses northward, taking advantage of the short, cool season. The areas left can be devoted to other crops that mature best during warmer weather. This northward movement can be easily mapped by noting the dates when new areas are first mentioned in the market reports.

Table 2 shows that lettuce shipments received in Cleveland rank second in importance, and that they are received from eleven different states. Table 1 shows that lettuce constitutes the largest vegetable shipment from California. Table 3 indicates that California lettuce outranks that of all other states in the Cleveland market. On Feb. 23 (see Map 2) Cleveland's lettuce was supplied by the Imperial Valley of California and the hothouses of Ohio.

The physical map shows the Imperial Valley as a triangular lowland bordered by highlands. The rainfall map records less than ten inches of precipitation during the year. The native vegetation map reports creosote bush and greasewood as the typical plant life. The soil map records gray or brown soils, typical of arid regions. Temperature maps show a January range from 50 to 60 degrees Fahrenheit, and a July temperature close to 86 degrees Fahrenheit. The growing season map shows

over 210 days free from frost. The sunshine map reports a high percentage of sunny days. The irrigation map shows irrigated land in the district.

The population map shows the district is thinly populated and separated from the dense urban population of the east by the thinly populated great plains. The railroad map shows lines extending from the district to the west coast and the cities of the east.

From the map data one pictures Imperial Valley as a lowland receiving little rain and covered with desert vegetation except where irrigated. The region has a cool winter and exceedingly hot summer. Where water can be supplied the growing season is long and is sunny.

Lettuce is a winter crop in Imperial Valley. The shipping lists of the Bureau of Agricultural Economics show the maximum shipments are made in January, February and March, at which time the temperature is low. No lettuce is produced in this region from May to November, since at that time the land is producing crops able to thrive in great heat. That this section has adequate transportation facilities is shown by the fact that the Southern Pacific in the course of the season moves some eleven thousand carlots of lettuce. The market is east but the handicap of distance is overcome since the market is in the grip of winter and demands the fresh product.

Through the application of irrigation waters Imperial Valley has been made a garden spot. Its long growing season enables it to send a succession of crops to eastern markets. These crops vary since some are adapted to the cool season and others to the season of maximum heat.

On Feb. 23, Ohio hothouse lettuce was also in the market. This was produced largely in the Cleveland district which occupies Cuyahoga and the eastern part of Lorain Counties. In this area there are one hundred fifty acres under glass, the largest hothouse vegetable area in the world. The hothouse lettuce however, is the leaf variety which is more perishable than head lettuce and less popular.

Lettuce is not the only hothouse vegetable supplied Cleveiand. Market reports list asparagus, cucumbers, tomatoes, rhubarb and mushrooms. A visit to any market will show many other staple vegetables that have been raised under glass and are able to compete with outdoor crops from the south and west. The hothouse vegetable industry has developed to great proportions,

Ohio leading all other states in the money value of the crops. The leading crops in the Cleveland district are tomatoes and lettuce. The Ashtabula district specializes in cucumbers, tomatoes and mushrooms; the Toledo district in lettuce and cucumbers. The Cincinnati district consists of many small producing areas so that the output is diversified. This latter situation holds in other areas in the state.

In adjoining states hothouses are engaged in vegetable production and are contributing to the Cleveland market. Indianapolis has some forty acres under glass. Terre Haute, Indiana, has the world's largest hothouse vegetable plant, twenty-nine acres under glass. This house specializes in cucumbers. Kankakee and Aurora, Illinois, and Davenport, Iowa, also produce cucumbers on a commercial scale. A fifty-five acre area at Grand Rapids specializes chiefly in lettuce. Hothouses near Detroit supply Cleveland with much of the early rhubarb.

Special maps can account for the location and success of the hothouse areas. They are in the regions of dense population and have excellent transportation to large markets. They are near the coal fields and also close to steel and glass production. Since the modern hothouse is ninety-five percent glass, and the wood has been replaced by steel, nearness to such building materials is essential. Since from two hundred to five hundred tons of coal are needed to maintain an acre of greenhouse at a suitable temperature for a season, nearness to cheap fuel is also essential.

This brief study is only a suggestion. Such investigations have practical possibilities. They deal with daily conditions concerning foods received from distant regions. The problems call for an intelligent use and interpretation of a variety of maps. The geography involved becomes significant and gives an appreciation of the dependence of the home upon distant food producing areas.

PRACTICAL FORESTRY FOR WISCONSIN CHILDREN.

Forty-acre tracts of land near schools in three communities in Forest County, Wis., have been donated to the schools by local citizens. They become the property of the schools to which they are deeded, and will serve as laboratories for nature study. Under the supervision of extension foresters of the State university trees will be planted by pupils of the schools at the rate of a few acres a year. Instruction will be given in thinning operations, the reduction of fire hazards, and other principles of forest management; and steps will be taken for the propagation of game and bird life. Similar projects are planned for other counties in Wisconsin.

A CHEMICAL VAUDEVILLE SHOW.[1]

IN THREE ACTS.

By Carl Otto and Harold B. Friedman.
University of Maine, Orono, Me.

Act I. The Grand Pageant of Alchemy.

The setting resembles an alchemist's laboratory. An old tripod with cloven-hoof feet, ancient apparatus supports, alembics and other curious forms of glassware, a clay oven with red light inside, and a porcelain burner in which the gas flame could not be seen, are distributed about the lecture table and form the setting for the act. A solution of KI for use during the act is boiling over the burner. The room lights are switched off and only the dull red glow from the oven illuminates the scene.

The alchemist costumed with gown and wig enters leaning heavily upon a staff and bearing a lamp and a large book with frayed and yellowed leaves. With a taper he lights alcohol in a dish and extinguishes the lamp.

Alchemist: (sniffing the air) Ah, what a smell this place has. It is musty. I must burn incense. (Lights a strip of magnesium ribbon from the alcohol flame and as it nears the end plunges it into a pile of flashlight powder. Meanwhile the assistant hidden behind the table has been painting a skull with a solution of phosphorus in olive oil. This is placed where the flash occurs, and as vision returns to the audience, it is dimly visible. While this is occuring the alchemist continues speaking.) Hermes! Greatest of the ancient alchemists! Thy book I have found and tonight I shall endeavor to achieve the ambitions of my profession by following thy directions. Aid thy humble follower with the universal knowledge thou hast gained since death. By thy most intimate presence guide my erring hands.

Voice of Assistant: Hermes is here.

Alchemist: (Lighting alcohol in a number of crucibles containing asbestos and inorganic salts giving flame colors.) I must have light to read. (Reads.) All things are of one substance. It is true and without falsehood, certain and most true, that which is above is even as that which is beneath. And that which is beneath is even as that which is above, for accomplishing the miracles of one thing. And as all things are from one by the

---

[1]This show was given by the authors under the auspices of the chemistry department of the University of Maine, on April 5, 1928, before an audience of students, faculty and friends. Several of the ideas included in the first act were derived from the article by R. D. Billinger, J. Chem. Ed., 3, 897-902 (1926.)

mediation of one, so all things were born from this one thing by adoption. Its father is the Sun, its mother is the Moon. The wind carried it in its belly. Its nurse is the earth. This is the father of all knowledge of the whole world. Its virtue is unimpaired if it should be turned towards the earth. (Pauses a moment and observes.) What clarity of thought! (Continues reading.) You will separate the earth from the fire, the subtle from the compact, gently with great skill. It ascends from earth to Heaven, then descends again to earth and receives the force of those above and those below. Thus you will possess the glory of the whole world and all obscurity will fall from you. This is the strong strength of all strength, because it will overcome every subtle thing and penetrate every solid. So was the world created. There will be adaptations of which this is the mode. Therefore, am I called Hermes Trismeigistos, having three parts of the philosophy of the whole world. It is finished, what I have said concerning the operation of the Sun. (Observes.) What wonderful words! What philosophy! (Continues reading.) The universal solvent I have discovered. Mountains crumble before it and become as the sea. And poured into the sea, the latter taketh flight as a bird and disappeareth into the air. Potent, indeed, is the owner of this secret. Take of the essence of serpents which has been purified thrice by fire and after the sun has set three hours in the constellation of Sagittarius, add oil of quicksilver which has been engendered under the light of the August moon at full. Mix equal parts and the result is attained. (Into a test tube having a hole in the bottom sealed with Canada balsam, barium chloride and conc. H_2SO_4 are poured. The latter in a few seconds eats through the balsam and the suspension of barium sulphate runs out.)

Ah, woe is mine. That which dissolveth all, I can not keep for it is sharp like the arrow points of Cupid. It penetrateth all and fleeth from all constraint. Let me read on and seek anew. (Reads.) Resurrection of Metals. Metals which have become debased may be regenerated by the following. Take thou copper bearing the imprint of the liberator and immerse in the aqueous extract of thrice distilled vinegar to which has been added six live spiders, three dead cockroaches, and a house fly caught in the palace of the king. Ah, I have the spirit, but where can I obtain copper bearing the imprint of the liberator?

(Alchemist turns towards place where assistant crouches.) Imp of Satan! Bound to me by thy master to do my slightest

wish. Arise! (The assistant wearing a gown and a red fez slowly appears from behind the table and bows.) Go forth and fetch me copper bearing the imprint of the liberator. None other will do. Return not until you find. (Assistant obtains a penny from someone in the audience. Mercurous nitrate is poured on this and the amalgamated penny is polished and returned.) Lo! the copper has been changed to silver. I shall be rich. But I must read farther. (Reads.) Secret of Midas, king of Persia. Expose the metal of Venus to aqua pura and when the debasing air has been expelled pour into boiling aqua pura. But drive away all evil spirits and gnomes and demons in order that this precious secret be kept. When the above is done the yellow metal of Jupiter will soon appear.

Imp! Seek me silver! (The assistant gets a dime from someone. For this a lead dime is substituted and placed in nitric acid. The assistant paints queer symbols on a large sheet of paper with a solution of phosphorus in carbon disulphide and hands this to the alchemist who waves it through the air driving out the demons, etc. When the phosphorus ignites it is held still a moment for the audience to see it. Then the lead nitrate is poured into the boiling potassium iodide solution, and the glistening golden flakes of lead iodide precipitate.) Eureka! By the almighty gods I am successful. I shall be rich beyond my wildest dreams. I shall be powerful for gold is power. (Turns over more pages of the book and reads.)

Elixir of Life. The elixir of life has long evaded me. I seem to approach it, but always fail. Thus I have done. On the sands of time I place salt of mercury and activated niter of Ammon. Moistened with oil of vitriol life seems imminent, but some influence is lacking. May he who reads these lines have better guidance by the gods. What! The writing grows! It continues! (Addressing the skull.) Hermes, you are communicating the secrets you have learned? Do—as—I—have—done—but—first—purify—thy—hands—with—fire. I—have—spoken. (The alchemist starts to hold hands over the alcohol burning in the crucibles, but draws back.)

Imp! Assist me! Pour this alcohol into my hands and ignite it. (This is done. A mixture of alcohol and carbon tetrachloride burns relatively cool.) Imp! Thou shalt not know the secret of life. I need thee no longer. Disperse! (A small heap of sugar and potassium chlorate is made on sand in which a stick of mercuric sulphocyanate is imbedded, and a drop of conc. H_2SO_4

is used to ignite the mixture. As the colored fire burns the mercuric sulphocyanate is ignited and forms the characteristic snake.) It grows! It lives! I am a creator! Nobody shall be as powerful as I. (The snake ceases to grow; the alchemist seizes it and it crumbles. He is crestfallen.) Alas, it grew. It lived. But I gave it no soul and the spark of life has vanished. I am weary and disappointed, and Aurora will soon appear in the east with her chariot. I must rest. (Lights lamp and extinguishes flames. Departs with head bowed low, carrying the lamp and book, leaning on the staff.)

INTERMISSION I.

A Symphony in Color.

Microscopic crystals of various substances are projected on to a screen by means of polarized light. Very gorgeous color changes may be obtained by rotating the plane of polarization.

ACT II. A BUNCH OF NON-SCENTS.

As will be seen in the following, the title of this act is not strictly accurate. The act consists of a number of carefully prepared experiments demonstrated to the audience with absurd explanations. The various setups are arranged on the two ends of the long lecture table from which they may be brought conveniently to the center for demonstration. The experiments are carried out alternately by the two characters. This permits one to be arranging the next demonstration while the other performs his. A and B enter from opposite sides.

A: Good morning. Haven't I seen you before somewhere?

B: Well, maybe so; I've been there.

A: Come here. I have a little *de*-vice I want to show you.

B: Sorry, I haven't but a minute to spare.

A: Good, tell me all you know, then.

B: What's a *de*-vice?

A: This is a photoelectric cell. (Holds up any peculiarly shaped metallic object). It's used for television.

B: Telle-what?

A: Television. Haven't you heard of television?

B: No. What is it?

A: Television, from the Greek word *tele* meaning er—ah— Say, have you ever heard of *tele*phone?

B: No.

A: (Thinking.) Tele— Have you ever heard of *tele*graph?

B: No.

A: You've never heard of television before?

B: No.

A: Well, you have now. When you strike a match and hold it near this *de*-vice, it generates a current which rings a bell. (Holds lighted match near cell. Electric bell concealed beneath table is operated by B's foot.) Will someone in the audience strike a match and hold it up? (B operates bell to correspond. Finally after several repetitions the trick is exposed by B's holding down the button when the light is out.) Hey, take your foot off. The light is out.

B: You know, I was visiting my uncle in Texas last summer, and watched some men drilling for oil.

A: Is that so? Oil well?

B: Yes, all well but my uncle. He was kind of poorly. I brought back a model of a gasoline well. Want to see it work?

A: If it does work, it will be the first I've ever seen.

B: We can try it. (Demonstrates the ammonia fountain with phenolphthalein in water.) See, it's a gusher.

A: That doesn't look like gasoline. It's all red.

B: Well this isn't a common gasoline well. This is ethyl gas.

A: Say, do you care if I smoke?

B: I don't care if you burn, but keep away from this gasoline. (A takes out cigarette, which has a mixture of Na_2O_2 and filter paper fiber in one end. Nonchalantly allows drop of water from dripping faucet to fall on one end. Cigarette lights itself. A attempts to blow smoke rings.)

B: I've got a machine that blows better rings than that. (Demonstrates preparation of phosphine, which forms rings on contact with air.)

A: Maybe I can blow better soap bubbles than I can rings. (Blows bubbles which drop into inverted bell-jar containing CO_2. Bubbles float suspended.)

B: I can make bubbles still lighter than that. (Blows bubbles with illuminating gas.) Strike a match and see how light they become. (A lights bubbles as each floats away.)

A: It's awfully warm here.

B: This is the first time I've ever heard you say you were too warm. You're always complaining about this cold weather with its snow and ice.

A: I like ice, but I want my ice in the summer time.

B: Well, how can you have ice in summer if it's not made in winter?

A: Down in Alabama, we raise ice whenever we need it.

B: Raise ice? What from?

A: Ice seeds. You buy a package at the drug store, and drop one in a bucket of water. (Demonstrates: drops crystal of $Na_2S_2O_3$ in supersaturated solution of same. This phenomenon is made more effective by illuminating this from below with all other lights out.)

B: By gosh, it is growing! That reminds me of how they make ice in Hell.

A: What were you doing there?

B: Just on a visit. Engaging a seat in the shade for you. (Demonstrates freezing of water with liquid sulphur dioxide in a red hot platinum dish.) Anyway this ice smells like H—. Have you ever seen any of Satan's writing?

A: No, I'm not on his mailing list. (B demonstrates; touches paper with hot file. Fire traces out writing which has been made with saturated potassium nitrate solution.)

A: That reminds me of how Boy Scouts make fire without matches.

B: How do they do it?

A: If they are out in a field without a match, they first light a Bunsen burner, warm up a glass rod, and plunge it into some water. (Lights carbon disulphide in clock glass with hot glass rod.)

B: That works all right, but how do they light the Bunsen burner?

A: What did you want to bring that up for?

B: I can make fire without a Bunsen burner. (Allows a drop of water to fall on a mixture of sodium peroxide and wood shavings.) This powder is called Wiseman's Wonder-Go and is sold by leading drug stores.

A: (Holding up beaker of dilute sodium hydroxide solution.) Say, would you like a little drink?

B: I don't drink water. It rusts my pipes.

A: Faith, and we'll soon fix that. (Pours into second beaker containing two drops of phenolphthalein solution.) How does this suit you?

B: O. K. But you better be careful. What if there is a prohibition agent in the audience? What then?

A: That's easier still. (Pours wine colored solution into third beaker containing a few drops of conc. sulphuric acid.) Now where's the evidence?

B: I've got a little potent stuff here myself. Want a swig? I'll split it with you. (Pours HCl from one pop bottle into a second containing a small amount of Zn.)

A: I never drink out of a bottle.

B: Here's a straw.

A: Is it clean?

B: I guess so. I've just let two others use it.

A: Then sterilize it for me. (B inserts straw fitted with stopper which fits bottle loosely and ignites same with a match. Explosion in a few seconds blows stopper to the ceiling No danger if thick walled pop bottle is used with loose stopper.) Well, that *is* potent stuff. I'm not so sure that I care for any of your fire water. I've got some real fire water. (Demonstrates burning of oxygen under the surface of concentrated ammonium hydroxide.)

B: Speaking of drinking makes me hungry. I think I'll make some sausage.

A: You have to have meat for sausage.

B: No, you don't. My grandfather was a butcher, but he got tired of killing hogs and invented a way of making sausage out of water. Here's how. (Into a test tube containing sodium amalgam pours saturated ammonium chloride solution. Quantities of sausage-like material issue from top of test tube.)

A: That reminds me of what my grandfather used to do. He used to keep a dairy, but he got tired of feeding cows and milking them so he learned how to draw milk out of the water faucet. (Draws water from water faucet into a milk bottle containing a little $SbCl_3$ solution.) He made ink, too. The process was very exact. It took exactly 25 seconds. If you don't believe it, time it. (Demonstrates "iodine clock" experiment.)[2]

B: Will Dean C. please step forward? (He does so.) This is a bit of experimental psychology. You've heard of psychology? (The Dean assents.) In fact, it involves memory. You have a memory, haven't you[3]?

B: Dean C., do you know what an Irishman does before starting a hard piece of work?

Dean C: He usually spits on his hands.

[2]See Foster's General Chemistry (Princeton University Press), page 197. Time must be determined previously by experiment. This is very effective if performers turn their backs to the apparatus and by lowering the arm indicate *exact* second the change should take place.

[3]At this point Dean C. nobly rose to the occasion and replied, "I don't need one. I've got a good secretary." She happened to be seated on the front row, and her astonishment caused much laughter by the audience.

B: Will you oblige by doing this? (He does. B holds up a small piece of cloth stained blue by dipping in $CoCl_2$ solution and drying.) You see this piece of cloth? Place it between the palms of your hands. Now show us which person in the audience is wearing a dress or a necktie of the same color as the piece of cloth you are holding. (He does so, and then compares with the piece of cloth, which, now pink, contrasts distinctly with the color chosen and gives the audience a laugh at Dean C's expense.)

B: (Discovers A meddling with the "wobbley bar.")[4] What are you fooling with there?

A: This is an invention of mine. It's a metal lighter than air. It defies the law of gravity and invokes the law of levity.

B: What are you going to use it for?

A: To make airplanes that will need no motor to sustain them in the air. They are going to be very important in the next war.

B: No, they are not. They will all be shot down with my death ray.

A: What's your death ray?

B: It's a vibration liberated by radium which when properly confined and directed utterly annihilates matter. Here's my death ray machine. (Exhibits a cardboard cylinder.) If the lights are turned out the radium can be seen shining out through it. (In the darkness opens the bottle of phosphorus in olive oil used in the alchemist act. This emits a greenish glow on contact with oxygen.) Lights on again, please. Now suppose that were an enemy aircraft up there. (Points to rubber balloon inflated with a mixture of hydrogen and oxygen and connected to ignition wires.) All I have to do is to point this machine, and there! (A presses button exploding balloon.) Now where would your airplane be?

A: Say, how about doing a little juggling?

B: Oh, I don't feel in a jugular vein.

A: Well, I think these people out here would appreciate a little. (A juggles several pieces of expensive glassware which are cracked and worthless, but seem good. B gets ready with the dust pan and broom. A finally lets piece after piece fall and smash. B busies himself with sweeping up the remains.)

INTERMISSION II.

[4]This consists of a magnet held suspended in the air by another magnet concealed in a block of wood. It was furnished by the Bell Telephone Laboratories.

Hit or Miss. A Musical Comedy. Piano by Pyrex.

On a xylophone, having a range of over two octaves including sharps and flats obtained by proper selection of beakers, a number of tunes are rendered with a stirring rod tipped with a rubber policeman. Each tune is introduced by absurd stories applied to various members of the audience.

Act III. Odds and Ends.

In this act a number of spectacular experiments are performed in rapid succession without being interspersed with dialogue. A short truthful statement of the materials being used is usually made. These experiments include the following:

Making a mercury hammer by freezing with CO_2 snow.

Chemical vacuum by interaction of NH_3 and HCl gases.

Chemical flower garden. (Growing crystals in Na_2SiO_3.)

Extinguishing lights with carbon dioxide gas.

Writing with the electric current. (Paper dipped in a solution containing starch, potassium iodide and phenolphthalein gives two colors by reversing the current.)

Combustion of phosphorus in oxygen.

Interaction of warm turpentine and chlorine gas.

Diffusion fountain.

Burning iron wire in oxygen.

Glowing of Pt wire in alcohol vapor.

Indicator color changes. (Ten indicators are used. The solutions are stirred with glass tubes containing NaOH or H_2SO_4 which barely drip from small holes in the bottom. The effect is of stirring with solid glass rods.)

Action of potassium on water.

Passive iron.

POTATO-TOMATO GIVES DOUBLE CROP.

A "good graft" (not of the political variety) which anyone may try, and which will reward a little patience with a double crop, is described in a recent bulletin of the Missouri Botanical Garden. It consists of a tomato vine grafted on a potato stock, which yields tomato fruits above and potato tubers below. The graft is fairly easy to make, it is stated, requiring no more skill than is needed for a similar operation on an apple twig. Apparently the first one on record was made over a century ago by an amateur scientist named De Tchudi, who reported his experiments to the Horticultural Institute at Fromont in France.

Neither partner in this double plant body seems to have any influence on the other. The tomatoes are like those of sister plants grown on their own roots, and the potatoes differ in no way from those grown in the ordinary way from other eyes cut from the same parent tuber.—*Science News-Letter.*

SOME CHARACTERISTICS OF THE PHILOSOPHY OF PHYSICS.

By Wm. S. Franklin,
Massachusetts Institute of Technology, Cambridge.

The limited usefulness in science of what we may, perhaps, call verbal philosophy has long been recognized, especially in the mathematical sciences. Unfortunately the term verbal philosophy conveys a suggestion of contempt, whereas no contempt whatever is here intended. By verbal philosophy we mean the marvelously effective method of thinking which all men use in their dealings with the complex problems of daily life, a method of which the most striking characteristic is the transformation of the essential phases of a problem into verbal forms, not solely for purposes of articulate speech, by any means, but to facilitate thought.

My own opinion is that the training of the mathematical physicist is vastly inferior to the training of a good lawyer as a preparation for dealing with complex human problems, and the lawyer's training is in verbal philosophy. I must, not, however, let this statement stand unqualified, for it needs to be qualified in two ways. In the first place scientific men would like to see the training of a lawyer arranged so as to lead to mental honesty as certainly as the training of the scientist, and in the second place scientific men would like to see a wider recognition among men of affairs (meaning the men who use what we have called verbal philosophy with great success in dealing with the almost infinitely complicated problems of practical life) of the fact that in every problem we face in this world the philosophy of precise ideas has come to have a place and that in most purely physical problems the philosophy of precise ideas is supreme.

An extremely remarkable thing in science is that highly complex and penetrating interpretations are forced upon the almost unthinkably meager data which we obtain directly through our senses. An astronomer, for example, *looks at a speck of light* as it crosses the field of his telescope and he *listens to the beats of a clock,* noting the time of day when the speck of light crosses the center of the field. He then *looks at a set of finely engraved lines* on a divided circle, noting the angular distance of the speck of light above the horizon. All this he does three times in succession. Then, proceeding to interpret his data, he calculates when the speck of light (a comet) will be nearest the sun, how far it will

then be from the sun, how fast it will be moving, and when it will return, perhaps a hundred years hence. This kind of forced interpretation is very common in physics and chemistry, and in most cases the actual sense data are so extremely meager that to the layman they seem to be absurdly inadequate.

Another equally remarkable thing in the physical sciences is that we have learned to exercise over physical things a kind of rational control which greatly transcends the cunning of the most skilful hand. A generation or two ago the most remarkable physical things grew out of manual skill; but the most remarkable physical things are now such things as the Boston Edison System, the modern steamship and the complicated radio set, and, as everyone knows, the design, construction and operation of such things depends so largely on the understanding that we almost forget the element of manual skill.

Francis Bacon long ago listed in his quaint way the things which seemed to him most needful for the advancement of human knowledge or power. Among other things, he mentioned "A New Engine or a help to the mind corresponding to tools for the hand"; and the most important aspect of the modern mathematical sciences is the aspect in which they constitute a realization of Bacon's idea. These sciences do certainly constitute a new engine which helps the mind as a tool helps the hand, and it is this engine which makes possible all forced interpretation and all rational control.

This new engine is in part a mechanical structure. Consider, for example, the carefully planned arrangement of apparatus which is always used in any physics research or in any engineering test, or consider the carefully planned series of operations of reaction, precipitation, filtering, drying and weighing that is always followed in any chemical study or test. The experimental data of the physicist and of the chemist are as meager as the astronomer's data and they take on meaning and bear a complex interpretation very largely because of the complex arrangement of apparatus or because of the inter-related operations, and, of course, the scheme of operations as well as the arrangement of apparatus is a mechanical structure.

The new engine is also in part a logical structure, that is to say, a closely reasoned body of mathematical and conceptual theory.

These two structures do indeed constitute a new engine, and the teaching of the physical sciences is the building of this

engine: (a) By developing the logical structure of the sciences in the mind of a young man, (b) by training in the use of measuring instruments and in the performance of ordered operations, and (c) by exercise in the application of these things to the phenomena of physics and chemistry at every step, and all the time, with every possible variation.

That certainly is an exacting program, and the only alternative is to place the student under the instruction of Jules Verne where nothing is to be done. There the student need not be troubled by exactions, but he can follow his teacher pleasantly on a care-free trip to the moon, or with easy improvidence embark on a voyage of twenty thousand leagues under the sea!

"Superiority to fate
Is difficult to learn,
'Tis not conferred by any,
But possible to earn
A pittance at a time,
Until to her surprise,
The soul, with strict economy,
Subsists till paradise."

Every person with whom I have ever talked, theorist or practician, student-in-general or specialist in whatever line, has exhibited more or less distinctly an attitude of impatience towards this or that phase of the precise modes of thought of the mathematical sciences.

Da wird der Geist euch wohl dressirt
In spanische Stiefein eingeschnurt
(There, alas, the spirit is constrained
And laced in a Spanish corselet.)

Consider the woodcraft of the Wild Indian; how marvelously adequate is the Indian's primitive sense of physical things! Nothing, however, is so essential in the mathematical sciences as the possession of precise ideas, because all of the forced interpretations and all of the national control in the physical sciences is effected by means of precise ideas. One must think in terms of precise ideas, there is no other way; and yet there is always a conflict in the mind even of the most willing student because of the severe constraint which accompanies the acquisition of precise ideas and because of the narrowing influence which precise ideas exercise over our vivid primitive sense of physical things. This conflict is perennial, and it is by no means a one-

sided conflict between mere crudity and refinement because refinement ignores many things. Precise ideas not only help most wonderfully to form our sense of the world in which we live, but they inhibit sense as well, and their complete and unchallenged rule would be a dreadful thing.

Grau, theurer Freund, ist alle Theorie,
Und grun des Lebens goldener Baum.
(All theory, my friend, is somber, gray;
And only the tree of life is green.)

It is the purpose of this brief article to set forth some of the little known characteristics of the philosophy of physics; of course it is not necessary to dwell on the best known phase of this philosophy, namely, the use in physics of the precise ideas of geometry, but in directing attention exclusively to the less widely known phases of natural philosophy we may be asking the reader to go farther than his limited knowledge can carry him.

A coin is rubbed on a board, work is expended on the coin and the coin undergoes a thermal change (the coin is heated). Let us suppose, for the sake of simplicity, that the only effect produced by the rubbing is the heating of the coin; then, if the coin were to be brought back to its initial condition by being brought into contact with another cooler body B, it would be found that the thermal effect produced in B is exactly what would be produced in B if the work expended on the coin were expended on B directly. Therefore, the coin, by virtue of the thermal change produced in it, has within itself something which is the equivalent of the work which has been expended on it, and this something is called heat. The definite outcome of these somewhat idealized operations involves the complete definition of heat as a form of energy, a definition which is sometimes called the first law of thermodynamics. If you do not believe it, try it! Every definition, every statement of principle or law of physics, rightly understood, is an actual operation, or grows out of operations, is or grows out of something done with the hands. How would you define a cow pasture? The answer is, by building a fence around it. Even a stupid cow pays attention to such a definition.

I am tempted to show the reduction of the principle of the conservation of energy in its purely mechanical aspects to an actual operation, but it is too long a story; [1]but the purely me-

[1]See pages 68 to 70 of Franklin & MacNutt's "General Physics," McGraw Hill Co., New York, 1916.

chanical principle is the outcome of a very definite group of operations, and the above described operational aspect of the first law of thermodynamics supplements the purely mechanical principle of conservation, giving us the complete principle of the conservation of energy. Most men, most physicists even (for we are all lawyers in our predilection for verbal philosophy), are content to think that they think that "energy can neither be created nor destroyed." Nothing is easier to hold in mind than this verbal statement, and few things are more difficult to hold clearly in mind than the complete operational aspects of the principle of the conservation of energy.

Most fundamental definitions in physics are what may be called mere locating definitions, "Here, putting your finger on the physical condition or thing, is what we wish to consider or talk about." In beginning the analytical study of heat the first thing to be recognized is temperature; arbitrary methods may then be easily devised for measuring temperature, but the student is usually impatient to know what temperature is! Now the function of the atomic method in physics is to develop conceptions of physical conditions and things, and the atomic method supplies a simple and well known conception of temperature, but the atomic conception of temperature is far less important than the recognition of temperature as a fact; go to a cellar where everything is shielded from outside disturbing influences, there things have settled to a quiescent state, there you will find a temperature! The trouble with mere locating definitions is their lack of conceptual material. Many men attend only to ideas and conceptions and never attend to so poor a thing as a locating definition! The above discussion of the first law of thermodynamics sets forth the mere locating definition of heat, but most men never even note this definition but think only of the atomic conception of heat.

And now for a matter that has been discussed *ad nauseam* by physics people. What is meant by mass? Very certainly the most important step in answer to this question is the locating definition; after this is settled one may proceed to learn many things about mass and the atomic method has come very near to supplying an atomic conception of mass (electromagnetic mass of the electron), but let us first of all recognize mass as a fact. Mass is one of the most important of the quantitative notions of physics and quantitative notions necessarily grow out of measuring operations. Our quantitative notion of length

grows out of the step-by-step operation of measuring by a yard stick, and very certainly the quantitative notion of mass must grow out of the operations involved in the measurement of mass. The only definition of mass for which one need offer no apology whatever is that *the mass of a body is what you get when you weigh the body on a balance*; this is the operational definition, but, because mass, like most quantitative ideas in physics, has many relations and because the relations of mass to force and acceleration are so remarkable, we forget ourselves and pretend to define mass in terms of acceleration, whereas neither the worker in the International Bureau of Weights and Measures nor your coal-man measures mass by jerking things around! You can easily frame up an operational definition of mass in terms of jerking, but measurement by the balance is the most precise measurement known, and the operation of weighing by the balance is the definition of mass in spite of any amount of reverence for Newton's laws of motion and in spite of any amount of verbal philosophy that may be brought to bear on the question. What you get when you weigh a body on a balance is independent of time and location, it is always the same for the given body, and it is for this reason that this result is a convenient measure for the amount of material in the body. The term weight as used in commerce (forget the spring scale as a device for weighing) means precisely the same thing as the word mass as used in science, and it is very greatly to the discredit of engineers that after agreeing to use the word weight in a different sense (meaning the force with which the earth pulls on a body) they revert to the usage of the coal-man, forgetting that the balance scale does not determine the weight of a body in the force sense.

In many cases the operational aspects of a principle or definition are difficult to hold in mind, thinking in terms of actual operations is very difficult; but operational philosophy is physics, and the difficulty of thinking in terms of operations is the difficulty of physics. What are you going to do about it? One thing we all do is to introduce terms and phrases, such as electric current, voltage, resistance, candle-power, 100° C., which relieve us of the necessity of long wordy specifications of underlying operations in making statements of physical facts, and which, unfortunately, mislead many men into the easy acceptance of physics as a purely verbal philosophy; and the utmost limit of this pseudo physics is reached when in answer to a question as

to the behavior of a body when acted upon by an unbalanced force the student answers *eff equals em aye!*

The most needed thing in physics is a logical scheme for facilitating our thinking in terms of operations, and it looks as if the phase of mathematics which is called the group theory might some day supply the much needed scheme. At any rate the operational aspect of physics sets physics apart from the familiar kind of pure mathematics, and, whereas, pure mathematics is the philosophy of precise ideas, physics is a philosophy of precise ideas and of operations. In both of these respects physics is to be contrasted with the age-old type of human philosophy in which the well-trained lawyer and the man of affairs excel.

A NEW MAP OF THE SALTON BASIN.

A new Geological Survey map has just been issued by the Department of the Interior covering the heart of the largest area in America below sea level—the Salton Basin of California. This basin includes the famous Imperial Valley, but its deepest part is covered by the Salton Sea, a large land-locked body of shallow, salty water with a shore line 250 feet below ocean level.

The lowest land in America is found in Death Valley, also in southern California—276 feet below sea level—but the area of that valley is only 450 square miles, as compared with 1,760 square miles in the Salton Basin. It is only of late years, however, that Death Valley has held even the low-level record. Prior to 1905 the Salton Basin was the lowest, lying 280 feet below sea level, but in that year the Colorado River went on an unusually wild rampage and broke through its banks some distance below Yuma, at a point where the water surface was about 50 feet above sea level and of course far above the Salton Basin. Through this break the great river poured into the Salton Basin, bidding fair to submerge the whole area, ruin the Imperial Valley and other valleys, and cause untold damage to property. Only the most heroic work by the Southern Pacific Railway averted a great disaster. Left to its own devices the river, after some years, would have created a great inland sea many times the size of the Salton Sea, and perhaps even larger than the Great Salt Lake of Utah. Even the water that flowed into the dried-up basin of the Salton Sea before the Colorado was finally reconfined within its banks raised the level of the Salton Sea from 280 feet to 244 feet below sea level. Since that event apparently 6 feet of water has evaporated.

Among the Indians of the region there is a tradition that many generations ago there was a similar influx of waters from the Colorado which filled the valley. It is probable that there have been several such occurrences during the last 2,000 years with long intervals between during which the waters of the lake gradually evaporated until it was reduced to dryness.

The map of the Salton Sea and Vicinity is engraved and printed on the scale of about 1 inch to 1 mile, and is sold by the Geological Survey, Washington, D. C., for 25 cents a copy.—Department of the Interior.

INITIATION CEREMONY OF THE EDISONIAN SCIENCE CLUB.

COMPILED BY LOUIS A. ASTELL,
West Chicago, Ill.

(The initiation ceremony takes place after the regular business meeting, when only members of the club are present. It should, of course, follow the annual campaign for membership. The symbols: (M) refers to music and (S) to appropriate slides, film-slides, or films. (For a more detailed discussion of the subject consult "Transactions of the Illinois State Academy of Science," Volume XX.)

PRESIDENT. We shall now proceed to the initiation. You are requested to remain in silence until the ceremony is concluded. The vice president will ascertain if there are any eligible students (or teachers) of this school seeking admission to the Edisonian Science Club.

(The vice president salutes the flag, which is placed at the right of the president's desk at such an angle that the president, the vice-president and the flag are in line; then proceeds to the adjoining room. Returning, he stands within the door and addresses the president.)

VICE PRESIDENT. Sir, I find the following who are qualified for membership in the Edisonian Science Club and who seek initiation therein. (He reads the names.)

PRESIDENT. You will conduct them into the meeting hall and place them properly before the flag.

(The vice president retires to the adjoining room, leads the candidates in file, to the tune of "National Emblem" or other appropriate march, before the president and addresses the president as follows before retiring to his station:

VICE PRESIDENT. Sir, I present these candidates for initiation into the Edisonian Science Club.

PRESIDENT. The solemnity of the occasion marks this as an hour most fittingly dedicated by prayer. Accordingly, the membership upon the sound of three raps of the gavel shall rise and stand in silence for thirty seconds in token of its foremost obligation to the Creator of all things. Upon the sound of one rap of the gavel all of the candidates will be seated. . . . Be so governed. (Raps.)

(After thirty seconds and following the single rap, he continues) The Edisonian Science Club, which is affiliated with the Illinois State Academy of Science, is founded on the ever-enduring corner stone of truth. Yesterday, today, and forever, truth was,

is and shall be with us—more certain than time itself, for it is the material of which time is made; admired by all; seen only in such degree as we are willing to remember that all things—whether animate, inanimate or spiritual—bear the unmistakable impress of the Divine Creator's hands. It is for us to remember that "Knowledge comes, but wisdom lingers"; that it is a part of man's duty to study, classify, correlate, interpret and build upon the truths of natural phenomena, for only through such activity may we hope in time to acquire wisdom. "The truth, the whole truth, and nothing but the truth" is the quest of those who propose to follow the beacon light of science. "Only genius can create science," but the humblest man may acquire its spirit. (Pauses.) The vice president will show you in further detail the finishing of this corner-stone, this ashlar of truth. (S)

Vice President (standing). The truth is stranger than fiction, and its revelation is worthy of all in all. With truth as our hammer the forge of life will ring for that higher and nobler purpose, the perfect brotherhood of man. "It is altogether fitting and proper, then," that you should behold at this time the necessity of truth in all the essential activities of your life, (S) work, play, love, and worship; for your success as an individual and as a citizen is not to be measured by worldly wealth but in terms of these four things. Without any one of them success in its fullest sense can not be. (Pauses.) The secretary will now instruct you in the object of this organization.

Secretary (standing). The object of this organization shall be to create and foster the best interests of science; to maintain its spirit; to further its methods; to promote relationships between those engaged in scientific work; to assist with investigations and to make known through discussions the material, educational, and other resources and riches of the commonwealth; to find in all these activities the vital correlations between the scientific, the social and the moral activities in this school and the community. It is for us to remember that our benefactor, Thomas A. Edison, has, through precept and example of work, contributed as largely as any other modern scientist to our present day comfort and happiness. This emblem (pointing to the pin which he should take care to wear on this occasion and then to the corresponding image on the screen) shall serve as a constant reminder of the wisdom obtained through knowledge, of the power that may come to the individual who walks uprightly and steadfastly by the light of the truth in scientific,

social and moral activities. (Pauses.) The treasurer will inform you concerning the emblematical significance of this organization.

Treasurer (standing). (Note. The picture involved at this point may be found in R. A. Gregory's, "Discovery, the Spirit and Service of Science," Macmillan, obtained at cost from The Chemical Foundation, Inc., 85 Beaver St., New York.) It is for me to paint a picture of that which, it is hoped, will remain with you throughout life. It is a portrait not of science but rather of the spirit of science which may be found residing within your personalities. Through this spirit, by lifting a corner of the veil, comes a new breadth of vision; a "new insight into the hidden meaning of things" about you; a growing realization of a greater freedom in the "world, rich in promise and of surpassing interest and wonder." With training, this spirit may be seen in every test tube, detected in the odor of every flower, and heard in the rush of electrons obedient to the laws of nature. In all places where man has the privilege of being, may the spirit of science be found, robed in the blackness of night to signify both the limits of man's vision and the fathomless depths of mystery in which he has found himself. (S) On her extended right hand is borne a white owl, emblematical of the purity and wisdom with which one may hope to look on the future; clenched in her extended left hand is a lightning bolt, symbolical of the command of limitless power; and, lastly, there is to be found coiled about her feet a large snake, indicating health and knowledge as a thing apart from wisdom. This is the spirit that may be heard to say: "I am what hath been, what is, what shall be. My veil hath been disclosed by none. The fruit which I have brought forth is this—the sun is born." Ours is the duty and privilege of bringing home to every man the wonders, the significance and the underlying or "inner harmony of things of the world in which we live, to the end that all undertakings may be better ordered, all lives enriched, all spirits fortified."

President (to candidates). You have heard the principles upon which this organization is based. Are you ready for the obligations?

Candidates. I am.

President (standing). You will repeat after me: I (here give your name) do solemnly and sincerely pledge myself to defend the truth as I see it; to serve the best interests of American democracy; to perform faithfully any and all duties entrusted to me by this—or any other—organization in the best interest

of science. (Pauses.) I am pleased to welcome you as members of the Edisonian Science Club. You will now sign the membership roll and take your place among the members.

(After the signatures have been obtained, the president calls for a motion for adjournment.)

Following this formal work, there should be a speaker, a regular program, or a film of appropriate nature, among the many possibilities. The following is quoted from a pamphlet: "A Message to High School Students of Illinois" from the Committee on High School Science and Clubs, for the year 1922-1923:

"The Council of the Academy authorizes the Committee of High School Science to state that high school science clubs may have a copy of the academy's Transactions on application to the secretary. The council also agrees to send to any high school science club, for its open meeting, a speaker of experience. The only cost to the club will be the speaker's traveling expenses. It is hoped that many science clubs will avail themselves of these offers."

References, Additional:

Meister, Dr. Morris, "Managing a Science Club," School Science and Mathematics, Vol. XXIII, No. 3, March, 1923. Note.—This paper was read before the Science Section of the N. E. A. Meetings in Boston, July 5, 1922.

"A Suggested Constitution for a Science Club." See pamphlet, "A Message to High School Teachers and Students of Illinois," referred to above. Suggest addressing C. Frank Phipps, Professor, State Teachers' College, DeKalb, Ill. If unable to locate the material, the writer will supply a modified constitution on request.

Wiggam, Albert Edward, "The Religion of the Scientist," World's Work, Vol. 50, No. 4, August, 1925.

Gregory, R. A., "Discovery, The Spirit and Service of Science," Macmillan. Obtained as one of a set of five books, each worth the total coast, from The Chemical Foundation, Inc., 85 Beaver St., New York, for the cost of printing: $2.50 the set. This book contains many pictures worthy of use in opaque or other projection in connection with the ritual.

"School Law of Illinois," Circular No. 202, "Fraternities." An act to prohibit fraternities, sororities and secret societies in the public schools of the state, and to provide for the enforcement of the same.

The initiation should be performed before the assembly once in four years—in the four year high schools—to conform with the spirit and the letter of the law.

Note.—Standardized cards of membership credentials for the individual members of the clubs and standardized pins for members of all clubs affiliated with the academy seem to be desirable objectives. For affiliation of clubs, address Dr. Lyell J. Thomas, Secretary, Illinois State Academy of Science, University of Illinois, Urbana, Ill., for application.

PROBLEM DEPARTMENT.

CONDUCTED BY C. N. MILLS,
University of Michigan, Ann Arbor, Mich.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution or proposed problem, sent to the Editor, should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to C. N. Mills, 204 Mason Hall, University of Michigan, Ann Arbor, Mich.

LATE SOLUTIONS.

1004. *Carlton Jencks, Lewis and Clark H. S., Spokane, Wash.*
1006. *Carlton Jencks, Kenneth Roberts, Ernest Roberts, Lewis and Clark H. S., Spokane, Wash.*
1010. *R. E. Morris, Lewis and Clark H. S., Spokane, Wash.*

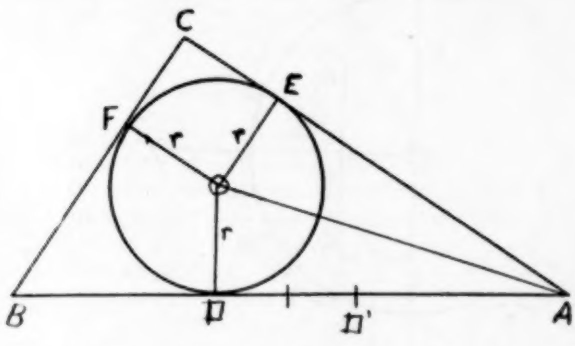
SOLUTIONS.

1013. *Proposed by E. de la Garza, Brownsville, Texas.*

Show that the area of a right triangle is equal to the product of the segments determined on the hypotenuse by the inscribed circle.

I. *Solved by Eileen Chu, Amoy, China.*

The right triangle OEA and ODA are congruent since three sides are equal respectively. OECF is a square.



AC = AE + EC = AD + r; CB = CF + FB = BD + r; AC − CB = AD − DB, hence

$(AC)^2 - 2\ (AC)\ (CB) + (CB)^2 = (AD)^2 - 2\ (AD)\ (DB) + (DB)^2$. Also, $(AC)^2 + (CB)^2 = (AD)^2 + 2\ (AD)\ (DB) \pm (DB)^2$.

Combining the last two equations by substracting one from the other, and dividing by 4, we have

(1/2) (AC)x(CB) = (AD)x(DB) = area of triangle.

II. *Solved by M. Freed, Phineas H. S., Los Angeles, Cal.*

See Figure for Solution I.

Let K represent the area of the given right triangle. 2K = (AE + r) (BF + r) = (AE) (BF) + r(AE) + r(BF) + r^2. Also K = CEOF + AFOD + BEOD = r^2 + (AE)r + (BF)r.

Substituting above, gives 2K = (AE)x(BF) + K. Hence, since AE = AD, and BF = BD, K = (AD)x(BD).

III. *Solved by George Sergent, Tampico, Mexico.*

See Figure for Solution I.

Let D and D′ be respectively the points of contact of the incircle and of the escribed circle opposite angle C, and the hypotenuse be AB. It is known that $DD' = a - b$, and that the midpoint of DD′ coincides with the midpoint of AB. Hence,

$$BD = c/2 + (a-b)/2,$$
$$AD = c/2 - (a-b)/2.$$

Multiplying, $BD \times AD = (c/2)^2 - [(a-b)/2]^2$.
Then, $4\ BD \times AD = c^2 - (a-b)^2 = c^2 - (a^2+b^2) + 2ab$.
Since $a^2+b^2=c^2$, $BD \times AD = (ab)/2 =$ area of the triangle.

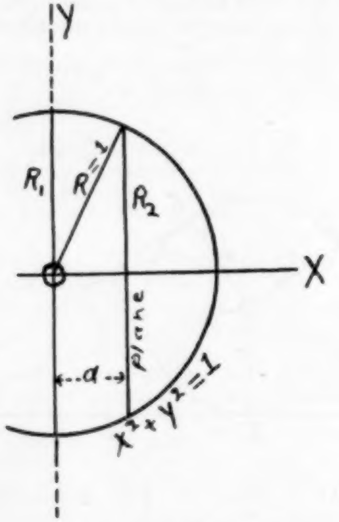
Also solved by *Bessie Green-Andrews, Wichita, Kansas; F. P. Hennessey, New York City; Floyd Sheel, Assaria, Kansas; F. A. Cadwell, St. Paul, Minn.; Lester McKee, Hartville, Ohio; R. T. McGregor, Elk Grove, Calif.; M. G. Shucker, Pittsburgh, Pa.; Warren C. Seyfert, Le Roy, N. Y.; R. A. Broman, Mishawaka, Ind.; Everett W. Owen, Oak Park, Ill.; J. F. Howard, San Antonio, Texas; Krystal Kegereis, Shortridge H. S., Indianapolis, Ind.; S. M. Turrill, Maywood, Ill.,* and the *Proposer.*

1014. *Proposed by George Sergent, Tampico, Mexico.*

A given hemisphere, of radius 1, is cut into two equivalent volumes by a plane parallel to the base. What is the distance from the center of the base to the plane? (Archimedes' Problem.)

I. *Solved by Elizabeth Blanchard, Lewis and Clark H. S., Spokane, Wash.*

Let a equal the altitude of the segment; R_1 the radius of the larger base, and R_2 the radius of the smaller base. Since the radius of the sphere is



unity, the volume of one fourth of it is $(pi)/3$. Placing the volume of the segment equal to $(pi)/3$ we have $a(pi)/2\ (R_1^2+R^2) + a^3(pi)/6 = (pi)/3$. Since $R_1 = 1$, and $R_2^2 = 1 - a^2$, we have after rearranging $a^3 - 3a + = 0$.

Solving this cubic equation by Horner's method, we find $a = .347$.

II. *Solved by Floyd Sheel, Assaria, Kansas.*

See Figure for Solution I.

Consider the volume of the segment as a volume of revolution, and setting up the required integral, we have

$$(pi)\int_0^a (1-x^2)dx = (pi)/3.$$

Hence, $\left[x-x^3/3\right]_0^a=1/3.$

Simplifying gives the same cubic as in Solution I.

A very neat solution was sent in by *Eileen Chu, Amoy, China.* In this solution use is made of the Duhamel Theorem which carries over into the form of the solution given by II.

Also solved by *Bessie Green-Andrews, Wichita, Kansas; R. T. McGregor, Elk Grove, Calif.; Sudler Bamberger, Harrisonburg, Pa.; Raymond Huck, Shawneetown, Ill.; J. F. Howard, San Antonio, Texas; M. G. Shucker, Pittsburgh, Pa.; R. A. Broman, Mishawaka, Ind.; S. M. Turrill, Maywood, Ill.,* and the *Proposer.*

1015. *Proposed by Orville T. Barcus, Columbus, Ohio.*

Show that all numbers of the form

$$2^{2^{12n+1}}$$

are divisible by 13 and 53, n being integral and greater than zero.

Solved by the Proposer.

The following tables show how the expression 2^{2^n} may be worked out using such divisors as 13 and 53. Numbers like 13, 53, 19, 853, etc., can be used as divisors of 2^{2n} since, by the theorem $(rp+1)/10$, they give 2^2, 2^1, 2^4, 2^8, etc., when p is 13, 19, 53, 853, etc., and r is 3, 1, 3, 3, etc., respectively.

Mod 13.

Rem.

$10 = 1 \quad (2^2)^{12} = 1 \quad \text{mod } 13$

$10^1 = 10 \quad (2^2)^{11} = 10 \quad \text{mod } 13$

$10^2 = 9 \quad (2^2)^{10} = 9 \quad \text{mod } 13 \text{ (X)} = 2^{2^3}, 2^{2^5}, \text{ etc.}$

$10^3 = 12 \quad (2^2)^{9} = 12 \quad \text{mod } 13$

$10^4 = 3 \quad (2^2)^{8} = 3 \quad \text{mod } 13 = 2^{2^2}, 2^{2^4}, 2^{2^6}, \text{ etc.}$

$10^5 = 4 \quad (2^2)^{7} = 4 \quad \text{mod } 13$

$10^6 = 1 \quad (2^2)^{6} = 1 \quad \text{mod } 13$

Mod 53

Rem.

$10^0 = 1 \quad (2^4)^{52} = 1 \quad \text{mod } 53$

$10^1 = 10 \quad (2^4)^{51} = 10 \quad \text{mod } 53 = 2^{2^8}, \text{ etc.}$

$10^2 = 47 \quad (2^4)^{50} = 47 \quad \text{mod } 53 = 2^{2^9}, \text{ etc.}$

$10^3 = 46 \quad (2^4)^{49} = 46 \quad \text{mod } 53 = 2^{2^{12}}, \text{ etc.}$

$10^4 = 36 \quad (2^4)^{48} = 36 \quad \text{mod } 53 = 2^{2^{10}}, \text{ etc.}$

$10^5 = 42 \quad (2^4)^{47} = 42 \quad \text{mod } 53 = 2^{2^5}, \text{ etc.}$

$10^6 = 49 \quad (2^4)^{46} = 49 \quad \text{mod } 53 \text{(X)} = 2^{2^{13}}, 2^{2^{25}}, \text{ etc.}$

$10^7 = 13 \quad (2^4)^{45} = 13 \quad \text{mod } 53 = 2^{2^7}, \text{ etc.}$

$10^8 = 24 \quad (2^4)^{44} = 24 \quad \text{mod } 53 = 2^{2^{11}}, \text{ etc.}$

$10^9 = 28 \quad (2^4)^{43} = 28 \quad \text{mod } 53 = 2^{2^4}, \text{ etc.}$

$10^{10} = 15 \quad (2^4)^{42} = 15 \quad \text{mod } 53 = 2^{2^6}, \text{ etc.}$

$10^{11} = 44 \quad (2^4)^{41} = 44 \quad \text{mod } 53 = 2^{2^3}, \text{ etc.}$

$10^{12} = 16 \quad (2^4)^{40} = 16 \quad \text{mod } 53 = 2^{2^2}, 2^{2^{14}}, \text{ etc.}$

$10^{13} = 1 \quad (2^4)^{39} = 1 \quad \text{mod } 53$

It will be noted that if 4 is added to both sides of the modulus marked (X) the expressions on the left will be divisible, in one case by 13, in the other by 53. It is obvious that the expression $2^{2^{12n+1}}+4$ when n is greater than zero) is divisible by both 13 and 53.

Some interesting results may be obtained from these tables. For example, it will be observed that $4x2^{2^{12n+7}}+1=0$ mod 53; also $4x2^{2^{2n}}+1=$

0 mod 13 (n in each case is greater then zero); also, $2^{2^5}+1=10 \bmod 13=43 \bmod 53$. This expression was believed by Fermat to be prime but we know it is equal to 0 mod 641.

1016. *Proposed by P. H. Nygaard, Spokane, Wash.*

Prove that the following expression is approximately true for small positive or negative values of d:

$$\log_e(N+d)=\log_e N+\frac{d}{N+d/2}$$

Solved by Eileen Chu, Amoy, China.

$$\log_e(N+d)=\log_e N(1+d/N)=\log_e N+\log_e(1+d/N)$$

$$\log(1+d/N)=d/N-(1/2)\,(d/N)^2+(1/3)\,(d/N)^3-(1/4)\,(d/N)^4+$$

As d is small all powers above the second of (d/N) may be neglected. Hence

$$\log(1+d/N)=d/N-(1/2)\,(d/N)^2$$
$$=(d/N)\,(1-d/2N).$$

$d/2N$ being small compared with 1, as an approximation

$$1-d/2N=\frac{1}{1+d/2N}$$

Therefore,

$$\log(1+d/N)=\frac{d}{1+d/2}$$

Hence

$$\log(N+d)=\log N+\frac{d}{1+d/2}$$

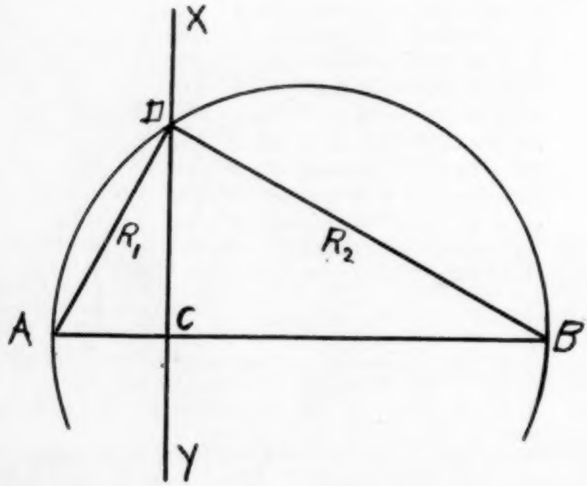
Also solved by *R. E. Morris, Lewis and Clark H. S., Spokane Wash.;* and the *Proposer.*

1017. *Proposed by Nathan Altshiller-Court, University of Oklahoma.*

If the polar of the center of one circle with respect to a second circle coincides with the polar of the center of the second circle with respect to the first circle, the two circles are orthogonal.

I. *Solved by F. A. Cadwell, St. Paul, Minn.*

Let A be the center of the first circle, and B the center of the second circle; let XY (intersecting AB at C) be the polar of the center of each



circle with respect to the other circle; let r be the radius of the first circle and r^1 the radius of the second circle. By hypothesis, ACxAB $= r^2$, and BCxAB $= r^{12}$. On AB as a diameter draw a semicircle intersecting XY at DM draw AD and BD. Since XY is the polar of A with respect to the circle whose center is B, it is perpendicular to AB, and since angle ADB is inscribed in a semicircle, it is a right angle. Therefore, ACxAB $= (AD)^2$ and BCxAB $= (BD)^2$. Hence, AD $= r$, and BD $= r^1$. Then D is a point of intersection of the two circles, and since the angle (formed by drawing a radius of each circle to this point of intersection) is a right angle, the two circles are orthogonal.

II. *Solved by M. G. Shucker, Pittsburgh, Pa.*

Let AB be the line of centers of the two circles of radii AD $= R_1$ and BD $= R_2$, and intersecting the coincident polars at C. *See Figure for Solution I.* By definition ACxAB $= R_1^2$, and BCxAB $= R_2^2$. Adding these expressions we get

$$(AB)\ (AC+CB) = (AB)^2 = R_1^2 + R_2^2,$$

which expresses the orthogonal relation.

Also solved by *George Sergent, Tampico, Mexico;* and by *Bessie Green-Andrews, Wichita, Kansas.*

1018. *Proposed by E. de la Garza, Brownsville, Texas.*

One of my customers returned 815 lb. of coffee at 13½ cents per pound and bought 865 lb. of coffee at 18½ cents per pound, paying in cash for the difference. I told him he had to pay the difference of price (5 cents per pound) on 1000 lb. of coffee. Prove algebraically (a) that I was right, and (b) that this and similar problems can also be solved by a simple addition.

Solved by Eileen Chu, Amoy, China.

The difference of price is:

(a). $865 \text{x} 18.5 - 815 \text{x} 13.5 = .1\ [(1000-135)185-(1000-185)135]$
$= .1\ [1000(185-135) - 135 \text{x} 185 - 185 \text{x} 135]$
$= 1000(18.5-13.5) = 1000 \text{x} 5.$

(b.) The first expression of (a) is a special case of AxB $-$ CxD, where $A+D=B+C$. Then $A-B=C-D$, and $A^2+B^2-2AB=C^2+D^2-2CD$.

$$2(AB-CD) = A^2+B^2-C^2-D^2,$$
$$= (A-C)\ (A+C)+(B-D)\ (B+D),$$
$$= (A-C)\ (A+B+C+D).$$

Hence $\qquad (AB-CD) = (A-C)\ (A+D).$

Example: $189 \text{x} 27 - 173 \text{x} 11 = (189-173)\ (189+11) = 16 \text{x} 200 = 3200.$

Also solved by *M. G. Shucker, Pittsburgh, Pa.*; *Robert Weaver, Lewis and Clark H. S., Spokane, Wash.*; and the *Proposer.*

PROBLEMS FOR SOLUTION.

1031. *Proposed by P. H. Nygaard, North Central H. S., Spokane, Wash.*

Solve for the smallest integral values of a and b:

$$a = \frac{938b+647}{229}.$$

1032. *Proposed by Glenn F. Hewitt, Fort Wayne, Indiana.*

Two regular hexagons, each side being four feet, form the bases of a hexagonal prism. The altitude of the prism is 12 feet. The lateral edges meet the plane of the base at an angle of 60 degrees. Find the lateral area.

1033. *Proposed by the Editor.*

A conical bin is to be made from a circular piece of sheet metal by cutting out a sector of the circular metal, no allowance for lapping. Required the angle of the sector for a maximum capacity, if the radius of the circular piece of metal is R.

1034. *Proposed by Melvin Weedon, Franklin, Indiana.*

Construct a square so that each side shall pass through a given point. (Altshiller-Court, College Geometry, Exercise 38, page 19.)

1035. *Proposed by I. N. Warner, Platteville, Wis.*

A clock loses 5 minutes each day of 24 hours. The clock is set right

at noon on Monday. What is the true time on Thursday when the clock shows noon?

1036. *Proposed by E. de la Garza, Brownsville, Texas.*

A father, upon the beginning of his son's High School education, deposited 10,000 dollars with a bank, at 4% compound interest, converted semi-annually. The money was not touched during the first four years: but at the beginning of the fifth year and continued for six years, 500 dollars were drawn every six months. Find the amount left in the bank at the end of the tenth year, when it is supposed the son left College.

SCIENCE QUESTIONS.

CONDUCTED BY FRANKLIN T. JONES.

Questions for discussion, examination papers, disputed points may be submitted to this department. They will be published together with discussion.

Please let us know what you are working on. It will be helpful to pass the information along.

Please send in tests and examination papers.

Send all communications to my home address—Franklin T. Jones, 10109 Wilbur Ave., Cleveland, Ohio.

QUESTIONS FOR ANSWER AND SOLUTION.

522. *Proposed by L. S. Guss, Senior High School, Austin, Minnesota.*

The Law of Universal Gravitation tells us that the force of attraction between the earth and some object in its vicinity varies inversely as the square of the distance between their centers. However, we know that the attraction is zero, if an object is at the center of the earth.

Where, therefore, is this force a maximum? Can this be proved without resorting to higher mathematics?

523. *Suggested by a recent auto ride on a gravel road.*

a Have you noticed the "washboard" or "corduroy" effect on slag, cinder and gravel roads?

b How do you explain it?

c Was there any such effect on roads before the days of the automobile?

d Did you ever on each type of road measure up the average interval between ridges to see if it is the same for gravel and for cinders?

524. *From John C. Packard, Brookline, Mass.*

July 6, 1928.

My dear Jones:

I am enclosing college entrance paper in physics—recalling that you are usually interested in "sich." A personal question or two:

Of what great use to a boy or girl is a knowledge of the facts involved in question four? As compared to the principal facts of radio for instance?

How many answers to 5 (c) besides "water," presumably used in reply to 5 (a) do you know?

How many answers to 5 (e) besides "quartz" are a matter of common knowledge, unless you bring in alloys of steel, etc.?

A perfectly fair paper as a test of results to be expected from the usual High School course, but, oh! if we could only get a little nearer to the life interests of the average boy and girl in our public schools.

Cordially yours,

J. C. PACKARD.

EXAMINATION PAPER.

PHYSICS

FRIDAY, JUNE 22, 1928, 2 P. M. TWO HOURS

Answer ten questions as indicated below.

Number and letter each answer to correspond with the questions selected.

Indicate clearly your reasoning in each problem and state the units in which each answer is expressed.

Part I.

(*Answer all questions in this part.*)

1. A diver is working at a depth of 40 feet in fresh water.
   a) What is the pressure (pounds per square inch) on the surface of his body due to the water?
   b) Would the pressure be greater or less in salt water than in fresh? Why?
2. A boat, 14 feet long, is slung up by two vertical ropes, one at each end. If the tension in the bow rope is 350 pounds and that in the stern rope 400 pounds, calculate (*a*) the weight of the boat and (*b*) the distance of the center of gravity from the stern.
3. A certain volume of air is confined in a cylinder having an air-tight piston. The pressure on the piston is now doubled, without change of temperature.
   a) What change takes place in the volume of the gas?
   b) What change in the density?
   c) If in doubling the pressure the temperature had been raised, would the change in volume have been greater or less? Explain.
   d) What early experimenter discovered the relation used in the first part of this problem?
4. a) What is the length of a closed organ pipe that has a frequency of 256 vibrations per second at a temperature of 20° C.?
   b) How do changes of temperature of the air affect the pitch of the pipe?
5. For each of the following cases, *first*, name some material which possesses the given property and, *second*, state a practical use of this material depending on this property:
   a) Large specific heat,
   b) Poor thermal conductivity,
   c) Large heat of vaporization,
   d) Low melting-point,
   e) Small coefficient of linear expansion.
6. The photograph of a child 4 feet high is to be taken by a camera the lens of which has a focal length of 9 inches. The child stands 10 feet from the camera lens. How large is the image?
7. Show by a diagram how you would arrange a voltmeter and an ammeter to measure the resistance of an electric flatiron. If the instruments registered 110 volts and 6 amperes respectively, (*a*) what would be the resistance of the coils, and (*b*) what power would the iron require for its operation?

Part II.

(*Answer only three questions from this part. No credit will be given for answers to extra questions.*)

8. The specific gravity of a given stone is 2.5. If a boy can lift 120 pounds, how heavy a stone can he raise to the surface of a pond?
9. On a certain hard-surfaced road the greatest retardation possible under ordinary driving conditions is 8 feet-per-second per second.
   a) What is the shortest time in which a car can be stopped from 30 miles per hour?
   b) How far will the car go while stopping?
10. A tin can, such as is used for oil, is filled to a depth of about 1 inch with water. The water is then boiled vigorously, and while steam is issuing from the opening, the screw cap is set tightly in place.
    a) What is the pressure inside just as the cap is secured?
    b) If the boiling is continued after the cap is in place, how will the temperature inside change? Why?
    c) What would happen if the boiling were continued long? Why?
    d) If the heater is removed as soon as the cap is tight, what change then takes place in the temperature inside? In the pressure?
    e) What is likely to happen to the tin can by the time the temperature within the can becomes that of the room outside? Why?

11. An iron ball weighing 10 kilograms strikes the ground after falling from a height of 100 meters. If 60 per cent of the resulting heat remains in the ball, what is its rise in temperature? The mechanical equivalent of heat is 0.427 kilogram-meters per calorie, and the specific heat of iron is 0.11.
12. *a*) What is the cause of refraction of light?
    b) What does the term "index of refraction" mean?
    c) If a book is held 1 meter from an electric lamp, it receives sufficient illumination. How many such lamps would be needed to get the same illumination with the book 3 meters away from them?
13. In order to measure the distance of a street lamp from his window, a boy fastens a sheet of paper 1 foot square on the glass and finds that the shadow on the wall opposite is 14 inches square. The room is 12 feet wide.
    a) What definite property of light is he using?
    b) How far from the window is the street light?
14. A shunt motor is to run on a 110-volt circuit. The resistance of the armature is .020 ohms. When running at full load, it takes 15 amperes.
    a) What is the back e. m. f. at full load?
    b) If the machine were thrown on the line while the armature was standing still, what current would it take?
    c) How would you control this starting current?
15. The following men have been pioneers in electrical progress. State briefly what contributions *five* of them have made: Ampere, Bell, Edison, Faraday, Franklin, Henry, Hertz, Ohm, Volta.

BOOKS RECEIVED.

Plane Trigonometry by Arthur M. Harding, Professor of Mathematics, University of Arkansas and George W. Mullins, Professor of Mathematics, Barnard College, Columbia University. Cloth. Pages vii+118. 12.5x19.5 cm. 1928. The Macmillan Company, New York.

Linear Difference Equations by Paul M. Batchelder, Ph. D., Adjunct Professor of Pure Mathematics, The University of Texas. Cloth. Pages vii+209. 15x23.5 cm. 1927. The Harvard University Press, Cambridge, Mass.

Success in Teaching Arithmetic, A Teacher's Manual to Accompany The New Everyday Arithmetic by Franklin S. Hoyt and Harriet E. Peet. Cloth. Pages v+320. 12.5 x18.5 cm. 1928. Houghton Mifflin Company, New York. Price 92 cents.

Laboratory Glass Blowing by Francis C. Frary, Director of Research, Aluminum Company of America, Cyril S. Taylor, Physical Chemist, Aluminum Company of America and Junius David Edwards, Assistant Director of Research, Aluminum Company of America. Second Edition revised and enlarged. Cloth. Pages x+116. 14x20.5 cm. 1928. McGraw-Hill Book Company, Inc., 370 Seventh Ave., New York.

College Algebra by Claude Irwin Palmer, Professor of Mathematics and Dean of Students, Armour Institute of Technology and Wilson Lee Miser, Professor of Mathematics, Vanderbilt University. First Edition. Cloth. Pages xiv+377. 12.5x18.5 cm. 1928. McGraw-Hill Book Company, Inc., 370 Seventh Ave., New York. Price $2.50.

Problem Exercises for High-School Teachers, Preliminary Edition by Douglas Waples in collaboration with W. C. Reavis, The University of Chicago and others. Cloth. Pages ix+99. 15x23.5 cm. 1928. The University of Chicago Press, Chicago, Ill. Price $1.00.

Drill Problems in Vocational Mathematics by William H. Dooley, Principal of the Textile High School, New York City. Cloth. Pages ix+195. 12.5x18.5 cm. 1928. D. C. Heath and Company, New York. Price $1.40.

Fun with Figures by A. Frederick Collins, Cloth. Pages xvi+253. 12.5x19 cm. 1928. D. Appleton and Company, New York. Price $2.00.

Food Products, Their Source, Chemistry, and Use by E. H. S. Bailey, Ph. D., Professor of Chemistry and Director, Chemical Laboratories, University of Kansas and Herbert S. Bailey, A. B., B. S., Formerly Chief, Div. Fats and Oils, U. S. Bureau of Chemistry. Third revised Edition. Cloth. Pages xviii+563. 13.5x20.5 cm. 1928. P. Blakiston's Son & Company, 1012 Walnut St., Philadelphia. Price $2.50.

Analytic Geometry by R. L. Borger, Ph. D., Professor of Mathematics, Ohio University. First Edition. Cloth. Pages xii+334. 12.5x18.5 cm. 1928. McGraw-Hill Book Company, Inc., 370 Seventh Avenue, New York. Price $2.50.

Yearbook of Agriculture 1927. United States Department of Agriculture. W. M. Jardine, Secretary, Nelson Antrim Crawford, Editor and Arthur P. Chew, Associate Editor. Cloth. Pages xxii+1234. 14.5x23 cm. 1928. United States Government Printing Office, Washington.

The Algae of Connecticut by Clarence John Hylander, Ph. D. State Geological and Natural History Survey, Bulletin No. 42. Paper. 245 pages. 14.5x22.5 cm. 1928. Distribution and Exchange Agent, George S. Godard, State Library, Hartford.

High School Chemistry by George Howard Bruce, Horace Mann School for Boys, Teachers College, Columbia University. Cloth. Pages x+550. 13x18.5 cm. 1928. World Book Company, Yonkers-on-Hudson, New York. Price $1.68.

High School Trigonometry by David Raymond Curtiss and Elton James Moulton, Professors of Mathematics, Northwestern University. Cloth. Pages x+94. 13.5x19.5 cm. 1928. D. C. Heath and Company, 239 West 39th Street, New York. Price $1.48.

The Elements of Astronomy by Edward Arthur Fath, Professor of Astronomy in Carleton College. Second Edition. Cloth. Pages x+323. 14.5x22.5 cm. 1928. McGraw-Hill Book Company, Inc., 370 Seventh Avenue, New York. Price $3.00.

A First Course in Physics for Colleges by Robert Andrews Millikan, Ph. D., Sc. D., Director of the Norman Bridge Laboratory of Physics, Pasadena, California, Henry Gordon Gale, Ph. D., Professor of Physics in The University of Chicago and Charles William Edwards, M. S., Professor of Physics in Duke University. Cloth. Pages xiii+676+xlii. 13.5x20.5 cm. 1928. Ginn and Company, 15 Ashburton Place, Boston. Price $3.72.

The Nature of Conduct by Percival M. Symonds, Associate Professor of Education, Teachers College, Columbia University. Cloth. Pages xi+346. 13x19.5 cm. 1928. The Macmillan Company, New York.

Principles of Plant Physiology by Oran Raber. Cloth. Pages xiii+377. 14x21.5 cm. 1928. The Macmillan Company, New York.

Exercises and Tests in Plane Geometry by David Eugene Smith, William David Reeve and Edward Longworth Morss. Paper. 160 tests. 19x24.5 cm. 1928. Ginn and Company, 15 Ashburton Place, Boston. Price 48 cents.

Exercises and Tests in Junior High School Mathematics, Part II by David Eugene Smith, William David Reeve and Edward Longworth Morss. Paper. 144 tests. 19x24.5 cm. 1928. Ginn and Company, 15 Ashburton Place, Boston.

Business Practice Exercises to Accompany Brewer and Hurlbut's Elements of Business Training by Harold E. Cowan, Head of Commercial Department, Dedham, Massachusetts High School and Harold W. Loker. Paper. 231 pages. 19.5 x23.5 cm. 1928. Ginn and Company, 15 Ashburton Place, Boston. Price 68 cents.

Flower Families and Ancestors by Frederic E. Clements, Ph. D., Carnegie Institution of Washington and Edith S. Clements, Ph. D., Carnegie Institution of Washington. Cloth. Pages x+156. 15x22.5 cm. 1928. The H. W. Wilson Company, New York. Price $2.40.

Elements of Physics by A. Wilmer Duff, D. Sc., Professor of Physics, Worcester Polytechnic Institute and Henry T. Weed, B. S., Head of Science Department, Girls' Commercial High School, Brooklyn, New York. Cloth. Pages ix+565. 13x19 cm. 1928. Longmans, Green and Company, New York. Price $2.20.

The Frog, A Laboratory Guide by Waldo Shumway, Ph. D., Associate Professor of Zoology, University of Illinois. Cloth. Pages viii+67. 12.5x18.5 cm. 1928. The Macmillan Company, New York.

Old Mother Earth by Kirtley F. Mather, Professor of Geology in Harvard University. Cloth. Pages xiv+177. 13.5x20.5 cm. 1928. Harvard University Press, Cambridge, Mass. Price $2.50.

An Outline of Physics by Albert Edward Caswell, Ph.D., Professor of Physics, University of Oregon. Cloth. Pages xiv+773. 14x21.5 cm. 1928. The Macmillan Company, New York.

Fundamentals of Biology by Arthur W. Haupt, Ph. D., Assistant Professor of Botany in the University of Calif. at Los Angeles. Cloth. Pages xii+358. 14.5x23 cm. 1928. McGraw-Hill Book Company, Inc., New York, 370 Seventh Ave. Price $3.00.

Trigonometry with Tables by Ernst R. Breslich, Assistant Professor of Mathematics, The University of Chicago and Charles A. Stone, Instructor of Mathematics in the University High School, The University of Chicago. Cloth. Pages xii+122. 13x19.5 cm. 1928. The University of Chicago Press, Chicago, Ill. Price $1.85.

Washburne Individual Arithmetic, One, Two, Three, Four and Five with Correction Book, Test Book, Key for Test Book and Teacher's Manual by Carleton Washburne, Superintendent of Schools, Emma Jaycox Koepke, Clauda Rogers McAfee and Frieda Barnett, Teachers in the Public Schools, Winnetka, Illinois. Paper. About 100 pages. 13.5x 20 cm. 1928. World Book Company, Yonkers-on-Hudson, New York. Price 40 cents except Key for Test Book, 48 cents.

Notes on Blow Pipe Analysis by Nicholas Knight, Professor of Chemistry, Cornell College, Mount Vernon, Iowa. Paper. 19 pages. 14x16 cm. 1928. Cornell College, Mount Vernon, Ia.

Building the German Vocabulary by Peter Hagboldt. Paper. Pages xvii+71. 10.5x17 cm. 1928. The University of Chicago Press, Chicago, Ill. Price 50 cents.

Organic Chemistry by Joseph Scudder Chamberlain, Ph. D., Professor of Organic Chemistry, Massachusetts Agricultural College. Cloth. Pages xxx+901. 14.5x21 cm. 1928. P. Blakiston's Son & Co., 1012 Walnut Street, Philadelphia, Pa. Price $4.00.

BOOK REVIEWS.

General Chemistry, by Azariah T. Lincoln, Professor of Chemistry, Carleton College and George B. Banks, Professor of Physical Science, Niagara University. 1st edition. Pp. xxii+681. 16x23x4.5 cm. Illustrated. Cloth, 1928. $3.50. Prentice-Hall. N. Y.

This text book is intended for first year college students. One of the noteworthy features of the book is that the order of treatment of the fundamental topics is based upon the electrochemical series of the elements. "The chemistry of the binary compounds is taken up in the order in which the nonmetals appear in the series." "The binary compounds of each non metal are discussed in the order in which the metal in them appears in the series." Whether or not there is any magic in this arrangement the reviewer will not attempt to say. As Ira Remson is said to have said, "You can teach chemistry to a chemist but it is almost impossible to teach it to one who is not a chemist." He doubtless meant that each new topic required a knowledge of other topics for its proper presentation so that, no matter what order you have followed, you will wish you had used some other.

The general treatment seems to be excellent. Industrial chemistry is especially strong and the processes well illustrated. There is more organic chemistry than one usually finds in an elementary college text and for those students who are not to go on with chemistry this is a valuable feature.

F. B. W.

College Algebra by Kenneth P. Williams, Professor of Mathematics, Indiana University. Cloth. Pages xv+312. 13.5x20.5cm. 1928. Ginn and Company, Chicago, Ill. Price $2.00.

The outstanding feature of this book is the method of attack. The author fully realizes the lack of interest many college freshmen have in the required mathematics and the very limited understanding they have of their high school work. To meet these conditions the fundamental operations are reviewed in the first three chapters, and the college work is definitely welded to the elementary courses. The object of each new chapter is pointed out to the student and he is told repeatedly of the advantages of algebra and its applications in the study of science, finance, statistics, etc. All discussions of theory are followed by several illustrative examples completely worked out. This insures a more careful study of the theory and encourages the student to master it. The topics are arranged in order of difficulty so that the student becomes familiar with the easier processes before attacking the more difficult. Repetition of difficult and fundamental ideas is frequent because the author believes that "it is by repeated study that one obtains an adequate understanding of the basis of a fairly difficult subject." Altho the text admirably links the elementary and advanced work it is in no sense merely a review of the secondary school course. From the beginning the student is taught to analyze and generalize. In the latter part of the book the principles of algebra are applied to the mathematics of finance, the theory of probability, series, and the theory of equations. The use of the graph is repeatedly illustrated and the solution of simultaneous equations by determinants is developed. G. W. W.

Sir Isaac Newton, 1727-1927. *Edited by F. E. Brasch.* Cloth. Pages ix+351. 15.5x23.5 cm. 1928. The Williams & Wilkins Company, Baltimore. Price $5.00.

"A series of essays giving a modern interpretation of the great English physicist through American eyes." These essays were prepared under the auspices of The History of Science Society in collaboration with other scientific organizations, as a bicentenary evaluation of his work. No higher recommendation can be given than to say that these essays were written by David Eugene Smith, Dayton C. Miller, George David Berkhoff, William Wallace Campbell, Michael Idovrsky Pupin, Paul R. Heyl, Ernest W. Brown, Florian Cajori, Lyman C. Newell, George S. Brett, George E. Roberts, and Frederick E. Brasch. They discuss Newton as a mathematician, a physicist, a philosopher, an astronomer, a chemist, a contributor to the progress of religious thought and as a citizen performing his duties as an official of the mint for thirty-one years. The essay by Mr. Brasch shows the influence of Newton on colonial education and discusses the work of his first great American disciple, John Winthrop IV. The book is a great contribution to the history of science library. G. W. W.

The Elements of Astronomy by Edward Arthur Fath, Professor of Astronomy in Carleton College. Second Edition. Cloth. Pages x+323. 14.5x22.5 cm. 1928. McGraw-Hill Book Company, Inc., 370 Seventh Avenue, New York. Price $3.00.

This is a revision of the author's very excellent text of two years ago. The subject matter has been amplified and corrected to include as nearly as possible all important discoveries made to the end of 1927. Eight star charts have been added. These charts are printed on one side of the paper only so they may be cut out and pasted on cardboard for convenient use. The book aims to present the subject matter of astronomy to college students who have had no mathematics beyond the ordinary high school courses. It is non-mathematical but discusses the physical principles and methods employed in astronomy. The topics covered and their order of treatment are the same as is found in other similar texts but the distinguishing characteristics are the author's easy, clear diction, and the artistic appearance of the book. The excellent quality of paper used makes the many half-tone illustrations stand out sharp and distinct like actual photographs. G. W. W.

An Outline of Physics, by Albert Edward Caswell, Professor of Physics, University of Oregon. Pp. xiv+739. 22x14 cm. 1928. New York. The Macmillan Co.

This is a college text-book in physics in which the organization of the material is determined not so much by the hard-and-fast rules of logical treatment but rather by the more reasonable psychological principles of the learning process. This statement is not to be construed to mean that logical treatment has been thrown to the winds: for the incorporation of the "new" physics with the classical material is sufficient to deny that. On the other hand the author does not feel constrained to dispose of summarily in an air-tight compartment the subject of Mechanics. He feels that there are aspects of Mechanics that the student can handle and appreciate quite early in the course; but there are phases of this topic to be found in the dynamics of linear and of rotary motion, for instance, that can quite profitably to the student be deferred toward the end of the course.

A little more than the first half of the book is devoted to the treatment of the essential facts of physics and their more obvious relations. The material is presented in a simple way, with many applications of the principles to arouse the interest of the student. A knowledge of simple algebra and occasionally an understanding of trigonometry is the only mathematical demand made on the student. Writers of text-books dealing with the general principles of physics are recognizing that there exists a broad and important field of physical phenomena that should be and can be made available to the general student without demanding familiarity with mathematics beyond simple algebra and in some connections a little trigonometry, and this book is good evidence of that attitude. It isn't until in the last half of the book that the more difficult topics of physics—rotary motion, harmonic motion and wave motion, for instance, engage the attention of the student. The treatment of these more difficult phases of physics is simplified by a free use of illuminating diagrams, which by the way are an outstanding feature of the book.

The recent developments of physics related to atomic structure, the origin of spectra, crystal structure, and questions involving the existence of the ether receive much more deserved consideration than is to be found in most books.

The summary at the end of each chapter and the numerous illustrative questions and numerical problems contribute vitally to the value of the book for college students and a favorable reception can be predicted for it. It is a book that the teacher of secondary school physics will like to have in his department library to which he can refer his curious students for such items as the Michelson-Morley Experiment, Michelson's method for finding the diameter of a star, X-Ray spectrometer, crystal structure, Millikan's method for finding the charge on an electron, etc. R. B. Z.

Advanced Algebra, by Herbert E. Hawkes, Ph. D., Professor of Mathematics in Columbia University. Pages VII+302, 14.5x21cm. 1928. Boston: Ginn and Company. Price $2.00.

This book is a revision of a text which has enjoyed a career of nearly twenty-five years. Professor Hawkes has attempted to keep the qualities which made the older edition popular and to make such changes as the new conditions demand.

The book is divided into three parts, viz., Algebra to Quadratics; Quadratics and beyond, which includes Mathematical Induction, Binomial Theorem; the Progressions; and Advanced Algebra, which includes such topics as complex numbers; Theory of Equations; Permutations; Combinations, and Probability, Determinants, etc.

J. M. Kinney.

Elements of Physics, by A. Wilmer Duff, D. Sc., and Henry T. Weed, B. S. Pp. 565. 19x13.5 cm. 1928. New York. Longmans, Green and Co. $2.50.

A text-book for use in high schools has as one of its distinctive features questions on the test material which follow immediately each numbered paragraph, so that the student "may test his understanding of what he has read." The authors recognize that many pupils do not seem to be able to pick out the essential thought in a paragraph—and hence this *Questions* device. It is also suggested by the authors that these questions may be helpful to the less experienced teachers.

The text-book follows the traditional organization of material under Mechanics, Sound, Heat, Light, Magnetism and Electricity. The style is simple and direct, easy of comprehension. Each section is followed by Exercises which stimulate the pupil to apply the principles discussed in the section. The numerical problems are plentiful after most sections—some sections might have more.

New material included consists of 3-color photographic transmission, cosmic rays, television and the earth inductor compass. The book includes illustrations showing the testing of an airplane member, cross-section of submarine models, arrangement of a sound-ranging station and some four dealing with aviation. R. B. Z.

Essentials of Trigonometry, by David Eugene Smith, William David Reeve, and Edward Longworth Morss. Pp. v+250. 14x19.5 cm. 1928. Boston. Ginn and Company. Price $1.44.

While writing this book the authors had in mind primarily the very large class of students who desire a practical knowledge of trigonometry. With this end in view they have emphasized only essential topics. The mathematical equipment of the student need not extend beyond the ability to use a simple algebraic formula, to solve a simple equation, to construct a graph, and to apply a few geometric facts.

There are seven chapters arranged in the following order. I. Preliminary work. This is written for students who need a review of the foundation topics mentioned above. II. Functions of an angle. III. Logarithms. IV. Solution of triangles. V. Analytic Trigonometry. VI. General applications. This chapter consists of general applications which may be used to supplement the work of each chapter or may be used for a comprehensive review. VII. The right spherical triangle. There is an abundance of interesting problems. Each chapter ends with a test exercise and a general review exercise. J. M. Kinney.

Senior Mathematics: Book I, by Ernst R. Breslich, Assistant Professor of the Teaching of Mathematics, the College of Education, and Head of the Department of Mathematics in the University High School, the University of Chicago. Pp. xxii+335. 13x19.5 cm. 1928. The University of Chicago Press. Price $1.50.

This book is a revision of Mr. Breslich's edition of 1915. It is an algebra in which "the fundamental concepts are given a concrete setting by relating them with intuitive geometry." The central aim in the course is to present algebra as a natural means of expressing quantitative facts. The arrangement of the material is psychological. That is to say, the simple mathematical concepts and processes are introduced first. For example linear expressions come first. These are followed by quadratics and expressions of higher degree.

The practical value of mathematics is stressed. For example, the simple numerical trigonometry is introduced early in the course. Provision is made for individual differences. Modern types of texts are employed. J. M. Kinney.

A Text Book of Organic Chemistry, by Joseph Scudder Chamberlain, Ph. D., Professor of Organic Chemistry, Mass. Agricultural College. Second Edition Revised. Pp. xxx+901. 16x21.5x4 cm. Cloth. 1928. $4. P. Blakiston's Son & Co.

Like its predecessor this text was written for the beginning course in college organic chemistry. It does not atempt to "temper the wind to the shorn lamb" but presents a lot of organic chemistry in as understandable a way as such a complex subject will permit. The book has been brought up to date by the addition of necessary new material and two new features have been added, "viz. a list of study questions and problems at the end of each chapter (a device which high school pupils have used to good purpose in most of the recent textbooks of inorganic chemistry) and references to laboratory preparations cited in Appendix II p. 847. These references will be found throughout the book in small black faced figures, placed with a compound or reaction. These figures are arranged in order in Appendix II, and following each is a list of references to books of laboratory preparations in which directions for making the compounds or carrying out the reaction will be found. The laboratory guides referred to include practically all that are published in English as well as three in German."

This is a thorough going text and the new edition maintains the standard of the first. F. B. W.

Common Wild Flowers of Pennsylvania, by E. M. Gress, Ph. D., State Botanist. First edition. Pp. 1-128. 13.5x20x7-10 cm. Pl. i-xii. Fig. 1-18. Paper. May, 1928. $.75. The Times Tribune Publishing Company, 1110 12th St., Altoona, Pa.

In this attractively written and well illustrated book Dr. Gress has expanded his very popular lecture on the Wild Flowers of Pennsylvania. Non-technical descriptions, myths, legends, peculiar characteristics of flowers and insect relationships combine to make the work unusually interesting reading in itself. While easily understood by the high school boy or girl, Dr. Gress' scholarly approach to his subject makes the book something more than the ordinary nature guide.

Not only the interesting subject matter but the practical form of the book itself commends it to the use of Boy and Girl Scouts and students and teachers of Nature Study—in fact to all who are learning to appreciate our wild flowers. N. M. Grier.

Modern Solid Geometry, by John R. Clark, School of Education, New York University, and Arthur S. Otis, author of Statistical Method Applied to Education. Pp. xix+139. 14x19.5 cm. 1928. Yonkers-on-Hudson, New York. World Book Company. Price $1.20. Bound with Plane $1.60.

This book is designed to follow the authors' Modern Plane Geometry, which was reviewed in this Journal, October, 1927. The numerous excellent features of that book are found in this one.

J. M. Kinney.

Plane and Solid Analytic Geometry, by James McGiffert, Rensselaer Polytechnic Institute. Pp. xiv+338. 15x21 cm. 1928. Boston. Ginn and Company. Price $2.48.

The author states that this book is the result of many years of experience with students in the Rensselaer Polytechnic Institute. We find the topics that are usually treated in the current texts on Analytics, plus a chapter on oblique coordinates.

The notion of derivative is introduced in the first chapter on the conics and is used on occasion throughout the remaining portion of the plane geometry. J. M. Kinney.

A Laboratory Manual in General Chemistry, by William Martin Blanchard, Professor of Chemistry, DePauw University. 14x21x2 cm. Cloth. Necessary diagrams. Pp. ix+196. Doubleday, Doran & Co., Inc. 1928.

This new laboratory manual is for use with the general chemistry course in colleges. It was primarily written to accompany "An Introduction to General Chemistry" by the same author. It contains 62 Exercises. Each right hand page is left blank so that the student can write brief notes as he performs the experiments. The amount of work included will require about six hours of work per week for a year. "The exercises are at once sufficiently simple to be performed independently by the average student; sufficiently comprehensive to give him considerable familiarity with the fundamental facts and principles of general chemistry and sufficiently varied to enable him to acquire a fair amount of skill in laboratory technique."

A careful scanning of a number of the exercises shows that the directions are carefully given, in language that should be easily understood by the student and that well considered questions are interspersed at suitable points in the work. F. B. W.

High School Chemistry, by George Howard Bruce, Department of Chemistry, Horace Mann School for Boys, Teachers College, Columbia University. 1st edition. Illustrated with photographs and with drawings by Will H. Schanck. Pp. x+550. Cloth. 1928. $1.68. World Book Co.

A brief study of this new high school text will at once command respect for what the author has done. The language of the book is such that the immature student can grasp it. The theoretical portions of the work are well distributed, following the presentation of the types of facts that they were intended to account for. We miss however any linking of the Gay-Lussac Law with the Avogadro Hypothesis although the latter was devised specifically to account for the former. A commendable feature of the book is the tabulation of properties of substances in vertical columns with the physical properties separated from the chemical. The treatment of valence is well timed and modern. The gas law calculations (Boyle's & Charles' are excellently taught. The content fulfills the requirements of both the College Entrance Examination Board and the Regents of the State of New York and also conforms to the requirements of the Syllabus of the Committee on Chemical Education of the American Chemical Society.

High School Chemistry teachers now have another fine text available. F. B. W.

A Guide to The Constellations, by Samuel G. Barton, Ph. D., Assistant Professor of Astronomy, University of Pennsylvania and Wm. H. Barton, Jr., C.E., M.S., Assistant Professor of Highway Engineering, University of Pennsylvania. First Edition. Cloth. Pages x+74. 23x30.5 cm. 1928. McGraw-Hill Book Company, Inc., New York. Price $2.50.

Anyone who wishes to become familiar with the constellations can do so by use of this book. A large chart for each month shows the positions and magnitudes of the principal stars visible to the naked eye in the United States. The page opposite each chart names the brightest stars and briefly describes the chart. In addition to the charts and their descriptions Part I contains several pages explaining the things most interesting to the beginner in the study of the skies, a table telling what chart should be used each hour, another giving important data for each constellation, and another for the brightest stars. Part II also applies to the United States and gives more detailed information of special interest to those pursuing a systematic study of astronomy. It consists of three detail charts and their description. Part III describes the constellations not visible in the United States. It contains one chart of the southern constellations showing 343 stars and one detail chart of the same with descriptions. G. W. W.

RUBBER, ALCOHOL BY CATHODE RAYS.

A new apparatus by which the waste products of petroleum stills and coke ovens may be quickly transformed into rubber, alcohol, acetic acid and valuable drugs and perfumes is announced by Professor H. Plauson of Hamburg, Germany. The active agent is the cathode ray, which is produced in the ordinary X-ray tube but which is here brought into the open, and made applicable to industrial processes on a large scale by Plauson's tube.

This, he claims, is more economical and efficient than that invented by Dr. W. D. Coolidge, the American physicist, in 1925. In the German tube the window through which the rays pass is of gold-plated beryllium instead of nickel. The current required is only 200,000 volts, while Coolidge runs his voltage up to 350,000 or higher.

A further advantage claimed by Prof. Plauson is that he is able to direct and focus the rays upon the chemical to be acted upon by placing it in a powerful rotating electro-magnetic field, which greatly enhances their activity. Under this influence moist air is converted directly into nitric acid. Ammonia is made from a mixture of nitrogen and hydrogen. The unusable gases given off in cracking petroleum to get the highest possible yield of gasoline can be combined with hydrogen or chlorine gas to form useful products. Synthetic rubber may be made from isoprene with astonishing rapidity. The milk from the rubber tree is quickly converted to a solid and insoluble state without the use of sulphur and becomes brittle if exposed too long to the rays. The liquid forms of bakelite are hardened into the solid shape without heating. With coal, water and air as the raw materials it is possible to make alcohol, methanol, acetic acid, ether and all such products as were formerly produced from vegetation.

Dr. Plauson says that the use of the cathode rays opens a new era in synthetic chemistry which is being actively investigated by the Laboratory of the Society for Ray Chemistry at Hamburg.

The cathode rays consist of streams of electrons, the minutest of all particles, driven off from the cathode of a vacuum tube. They are not capable of passing through the glass of the tube, but where they strike they start a stream of X-rays which are immaterial and more speedy and so penetrating that they will pass through the human body and thus enable you to see pictures of your bones. The X-rays were discovered in 1896 by Roentgen, a German physicist, and in 1894, Lenard, another German, found that the cathode rays could be let out of the glass tube by a little window through a pane of aluminum foil.

But the most powerful X-ray tubes were invented by Dr. W. D. Coolidge of the General Electric Company, Schenectady; and in 1926 he got cathode rays in abundance by closing the end of the tube opposite to the cathode by a window of nickel, three inches in diameter.

The rays so released are found to have amazing effects on chemicals and on plants and animals. Castor oil, exposed to the rays, becomes solid. Acetylene gas was converted into a brown powder that could not be dissolved. When a rabbit's ear was placed in the path of the ray the hair came off, and when it grew again it was white.—*Science News-Letter.*

REPORT OF SPECIAL STUDY BY U. S. PUBLIC HEALTH SERVICE OF THE VISION OF 1,860 SCHOOL CHILDREN.

The United States Public Health Service, with the cooperation of the Departments of Health and Education of the District of Columbia, has recently completed a thorough examination of the vision of 1,860 white school children in Washington between the ages of 6 to 16 years. These children were not a selected group and the conditions disclosed may be regarded as representatives of those existing generally not only in Washington but in schools throughout the country.

This study, the significance and value of which cannot be over-estimated, was most thoroughly and scientifically carried out, and according to the Eye Sight Conservation Council, this investigation is the most thorough and complete study of the visual condition of a large group of school children ever conducted under such favorable conditions. The examinations of the children comprised both the simple visual test made with the test letters of varying sizes and also a thorough refraction of the eyes of each child with the accommodation of the eyes suspended which disclosed the total amount of existing defects.

The results of these thorough eye examinations of the 1,860 school children revealed the following condition: only 3.4 per cent of the children were found with eyes free from refractive defects, the visual defect most frequently prevailing was far-sightedness (hyeropia) of which there was 63 per cent. Near-sightedness (myopia) affected 5.5 per cent, and astigmatism 28 per cent. This extremely large proportion with eye defects included all with slight errors not needing correction but the conclusions reached by the experts in the Public Health Service were that glasses were needed by 34 per cent of the entire group and that glasses were recommended for reading and studying for an additional 10 per cent.

An outstanding feature emphasized by this investigation is the fact that the simple visual acuity test reveals but a small percentage of the actual number of refractive errors in children. The reason for this is that the accommodation of the eye—that remarkable adaptability which enables the eye to focus instantly on objects at a distance or near by—is so strong in the young that it overcomes errors of refraction of the far-sighted (hyperopic) type. While the simple eye tests made with various sizes of letters "as conducted in the schools, are of much benefit, only the children who have marked visual defects are discovered; a great number are found to have normal vision and are so informed when in reality they are suffering with latent defects. Strains of varying amounts are present which may become worse as the child advances in its school course. The individual goes out into the commercial world much handicapped due to the effects of visual defects."

In this investigation the preliminary simple visual acuity test indicated that 34 per cent of the children had defective vision and 66 per cent had normal vision whereas with the accommodation suspended and thorough examinations made an extraordinary change was shown.

The group which had standard vision or better before accommodation was suspended showed an enormous drop when the accommodation was neutralized, and nearly one fourth of those in this group dropped from standard vision to but 30 per cent vision or worse. A most astounding change was found as to the proportion showing very defective vision. Before the accommodation was neutralized 7% of the children were in the group having but 40% of standard vision or less but after accommodation was suspended this group increased from 7% to 43%. Many of the children with standard vision or approximately 75% of standard had but 20% of standard vision when the accommodation was suspended and the hidden defects disclosed indicating at what a burden of eyestrain and expense of nerve energy they were using their eyes.